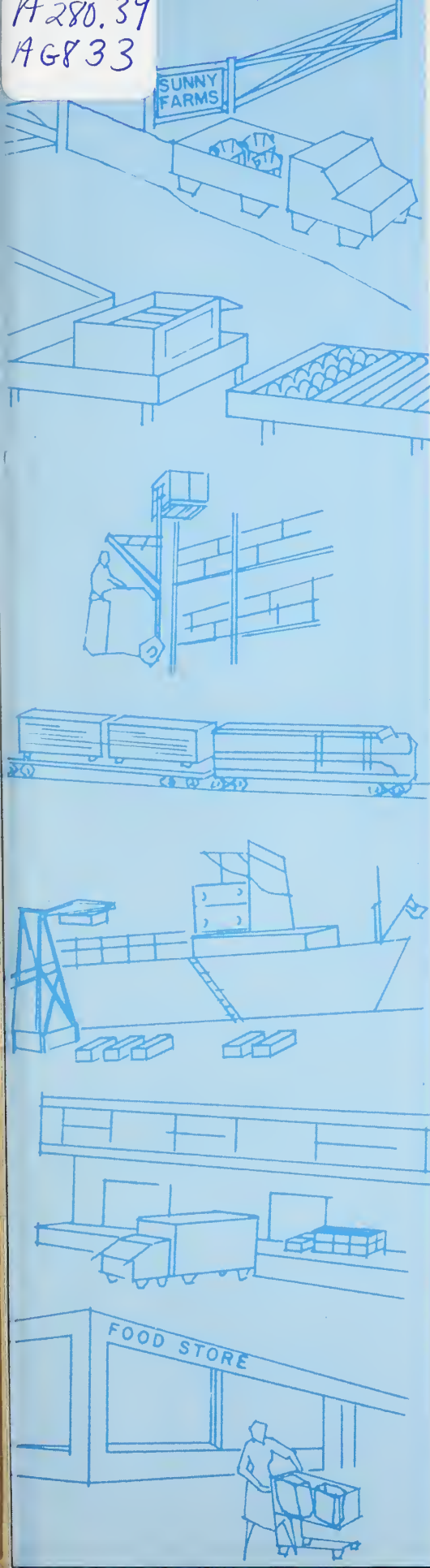


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PROGRESS REPORT
OF THE
TRANSPORTATION
AND FACILITIES
RESEARCH DIVISION

MARKETING AND
NUTRITION RESEARCH

JULY 1, 1971

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UNITED STATES
DEPARTMENT OF AGRICULTURE

This progress report is not intended for publication, as the summaries of progress include some tentative results that have not been tested sufficiently to justify general release. Copies are distributed only to members of the Division staff and others having a special interest in the Division's research programs.

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PROGRESS REPORT
OF THE
TRANSPORTATION AND FACILITIES RESEARCH DIVISION
MARKETING AND NUTRITION RESEARCH

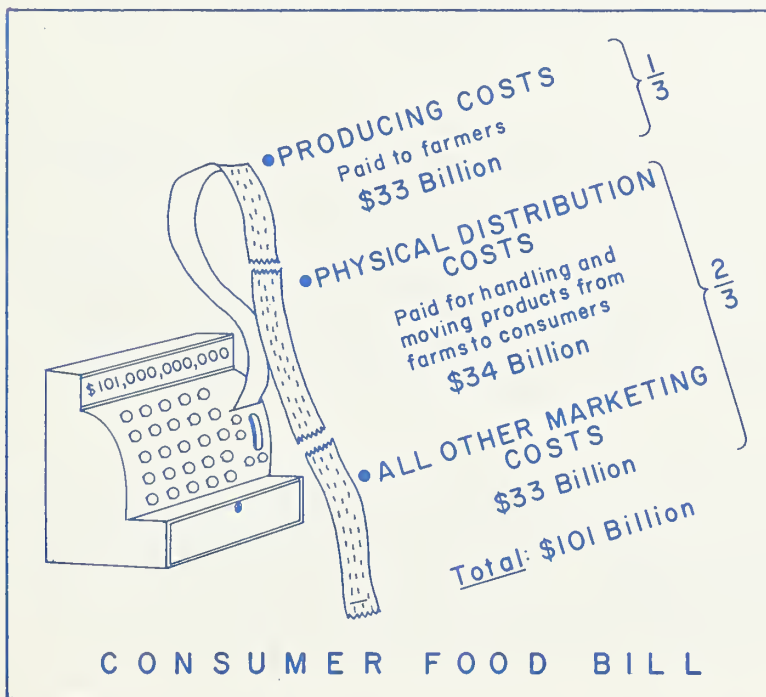
July 1, 1971

INTRODUCTION

The transportation and marketing facilities research of ARS is concerned with the physical distribution costs of marketing farm and food products from the farm to consumers. It seeks to find ways to improve handling methods, equipment, containers, operating procedures, and facilities to increase their efficiency and effectiveness, increase labor productivity, and help hold down marketing costs. The functions to which these physical elements relate are assembling, preparing for market, processing, packaging, pre-cooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution.

Our system of producing and distributing food supplied consumers with \$101 billion worth of food in 1970. It cost \$33 billion for growing the food and \$68 billion for marketing it. The cost of physically handling food during the marketing process requires about one-half of the total marketing costs, or

approximately the same as the cost of growing it. This half of the total food-marketing bill is the one that is directly affected by research in the areas covered by this report. In 1970, about four-fifths of the increase in the marketing bill was attributed to the higher costs of labor, packaging materials, and other services and goods required by marketing firms. Hourly labor costs increased nearly 8 percent during 1970.



To accomplish effectively its mission of finding ways to help hold down physical distribution costs, the Division selects

with great care the problems on which to work. Among the guidelines used for selection are: The importance of the problem, the benefits obtained in relation to the cost of the research, the possibility of success, whether the problem is being or can be worked on by others, and how much help is available from others in the form of facilities, personnel, commodities, and funds. (The contributions of others to Division work exceeds the Federal appropriation for the work.) Division proposals for improvements in physical distribution sometimes require heavy investments by industry or local governments in facilities, equipment, and methods; therefore, the proposals made must meet today's needs and, with minor modification, the conditions expected to prevail in the years ahead.

Two basic methods are used in Division research: (1) Finding ways to improve the specific parts of the system and (2) finding a better way to put the parts together. In its work to attain these goals, the Division works with and in the facilities of firms engaged in marketing and utilizes the services of people with a variety of skills--people who have imagination and who are not afraid of change.

The Division frequently serves as a catalyst by stimulating and organizing the combined research effort of State and private groups who are concerned with marketing problems. It further serves as a catalyst through consultations of its personnel with hundreds of people throughout the country who are wrestling with these problems.

Of course, none of its research would be worthwhile unless the results and recommendations were made available to those who need and can apply the information. Therefore, the Division uses every means and opportunity possible to make these results known. Some of the methods used are: Research publications, articles in magazines and trade papers, speeches at professional and trade meetings, radio and television presentations, movies, models, clinics and seminars, and getting others to talk and write about Division research findings.

Division research has been oriented to solving high-priority marketing problems. Severe inflationary pressures on food prices have placed research to hold down handling costs in the highest priority category. The need for a special type of food distribution facility for low-income families is being recognized by research to develop such facilities. Concern with environmental problems has resulted in projects to clean up processing plant wastes, develop packages that can be disposed of more readily after use, and develop systems for handling recyclable solid waste. Improved packaging and transportation systems for overseas shipments have made notable contributions toward decreasing our export deficits.

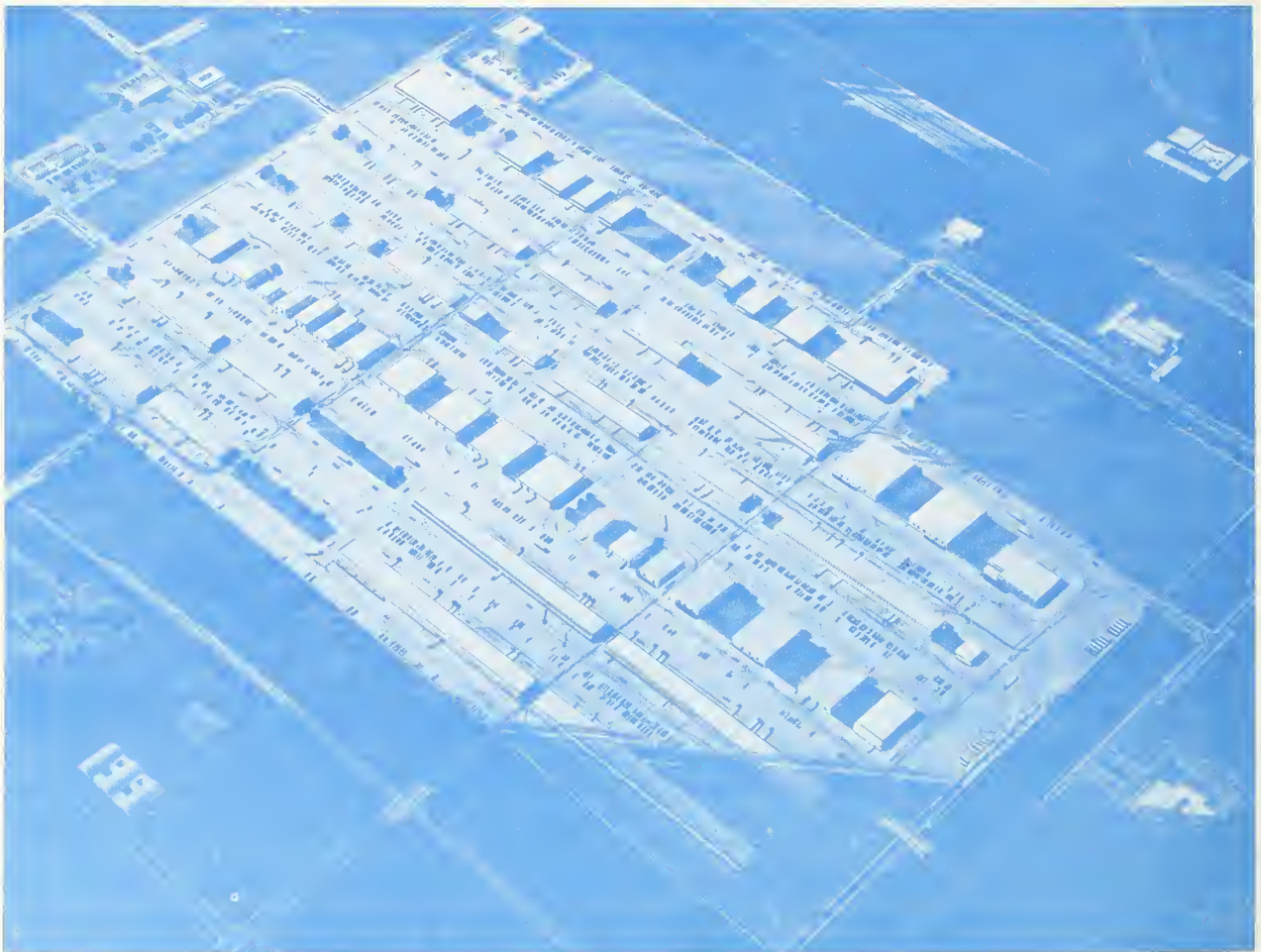
The research undertaken during the past two decades to make marketing more efficient has been effective. The average labor cost per unit marketed has increased only about one-third as much as the average wage rate paid for the labor required in marketing activities. If the full increase in the cost of labor during the past two decades had been reflected in marketing costs, the total food marketing bill for 1970 would have been about \$18 billion greater than it was.

This report presents the highlights of the work done by the Division during the past 12 months. Further information about any of the subjects discussed in the report can be obtained by contacting the Director of the Division, William C. Crow, U.S. Department of Agriculture, Agricultural Research Service, Transportation and Facilities Research Division, Room 849, Federal Center Building, Hyattsville, Maryland 20782. Telephone--Area Code 202, 388-8721.

EXAMPLES OF ACHIEVEMENTS

Wholesale Food Distribution Center Planned for Los Angeles

On June 16, 1971, the results of one of the largest studies ever undertaken by the Transportation and Facilities Research Division were presented in Los Angeles. Over 600 representatives of the Los Angeles City Council, the Mayor's Economic Development Board, the Board of Public Works, food distributors, banks, insurance companies, and the news media heard the Division's recommendation for improved wholesale food distribution facilities to serve greater Los Angeles. The recommended plan calls for the acquisition of about 470 acres of land for the construction of facilities designed specifically for handling food. Over 2 million square feet of first floor space would form a nucleus of facilities capable of being expanded by more than 50 percent to keep pace with the rapidly growing Los Angeles area.



Proposed wholesale food distribution center for Los Angeles.

The overall plan is designed to eliminate the major physical problems that exist in the wholesale marketing of food in Los Angeles. Ample building space is provided for all firms that presently need new facilities. Wide streets would permit traffic to flow freely into, within, and out of the market area without delay. Plenty of parking space and proper receiving and shipping docks would permit loading and unloading at a minimum cost. Adequate entrances to the facilities would provide for uncongested receiving and shipping operations. Rail tracks direct to the wholesalers' facilities would eliminate the double handling and the carting of rail receipts. Space would be available for expanding the initial facilities and for constructing new facilities for other firms that will need to relocate in the future. A centralized refrigeration system would produce all of the refrigeration at a minimum cost and distribute it through a network of underground pipes to the wholesalers who require it. Owning and operating this system will cost only about three-fifths as much as individual systems would cost.

The plan for the new food distribution center calls for initial construction of 53 buildings. Fifty would be for 244 wholesalers who presently need new facilities. The other three would be a public refrigerated warehouse, an office building, and a central refrigeration plant. The total cost for all the facilities recommended for the handling of food, including a centralized refrigeration system, would be between \$72 and \$103 million, depending upon which of five sites is selected.

Many facilities presently utilized by food wholesalers are inadequate, inefficient, and costly to use. Of these, few have adequate receiving and shipping docks, some have inadequate entrances for receiving and shipping, and many are crowded inside, either because of poor design and layout or because the wholesaler has outgrown the facility. Most of the present facilities have little or no room for expansion.

Some wholesalers have operations in two or more facilities and must provide for duplication of many handling functions. Some have no refrigerated space for storing products that require refrigeration, and others have insufficient refrigerated space. Some firms that receive products by rail have no tracks to their facilities and must cart their receipts from team tracks several miles away.

Efficient operations are impossible in some of the market areas because of heavy traffic congestion. Poor accessibility and narrow service streets restrict the free flow of market traffic and result in costly delays to trucks. Parking is extremely limited. Welfare facilities for employees are often inadequate. The hours of operation are long and the labor is difficult because of the lack of proper facilities and handling equipment.

Within 5 years the Los Angeles food distribution system may be required to handle 50 percent more food than is being handled today, a burden that could be too great for the presently overtaxed facilities. Most deficiencies cannot be corrected by remodeling--completely new facilities are needed.

A Potato Storage in-the-Round

A new concept in potato storage layout has been developed which utilizes a circular arrangement of potato storage bins so that several hundred thousand hundredweight (cwt.) of potatoes can be stored under one roof. Storage in the new design is arranged compactly around a central work area from which interior walls radiate like spokes of a wheel to separate the storage bins.



Artist's concept of the exterior of the circular potato storage.

Present storage facilities are rectangular. In large facilities, therefore, potatoes must be moved several hundred feet within the building during the process of preparing them for market. Since a circle provides a maximum area within a minimum perimeter, the circular layout provides more actual storage space than a rectangular layout. In addition, it provides for greater efficiency through a maximum of bin entrance space for filling activities and a minimum of bin exit space for emptying activities.

The wide exterior bin openings, plus a wide expanse of exterior yard space, enable the growers to get their crop under cover quickly and easily in large storages by providing the necessary working space for the large, high-capacity equipment used to fill many bins simultaneously at high handling rates. Thus, the maintenance of the product quality is enhanced, and the possibility of product losses is reduced.

Since the stored potatoes must fill the requirements of the market over an 8- to 11-month period, the storage bins are unloaded only one or two at a time, at a relatively low handling rate, with a minimum of equipment and activity. The smaller bin openings and compact work area in the center of the storage provide space suited to the unloading activities.

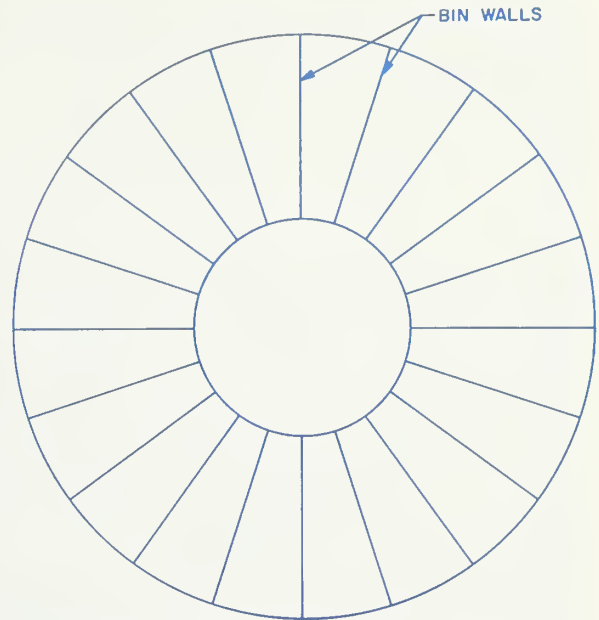
A feature of the circular storage that further enhances its efficiency is its adaptability to the use of powered bulk scoops for handling potatoes.

The use of powered bulk scoops is known to increase the efficiency of handling potatoes in rectangular storages when the haul distances are short; even in a storage facility as small as 240,000 cwt., handling costs are reduced by \$7 per 1,000 cwt. Based on a 100-million-cwt. annual volume, and assuming a 20-year life for the circular storage facilities, savings in handling alone would exceed \$14 million.

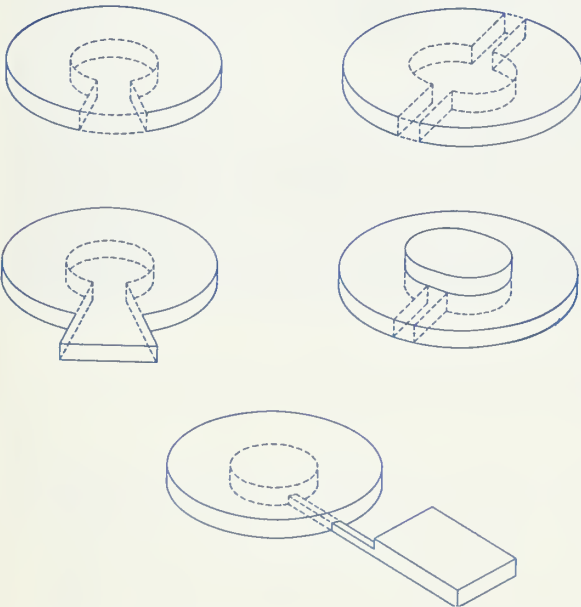
Market preparation facilities, such as packinghouses and processing plants, are entirely compatible with this storage layout, and both inside and outside loading facilities for trucks and railroad cars can be provided.

The storage operator will be able to store potato lots so that they are readily accessible for inspecting and sampling and for taking instrument readings and adjusting the environmental control system.

This system, which consists of fans, heaters, and refrigeration equipment, may be either an individual system for each bin or a large, centralized system.



Drawing of the interior layout of the circular potato storage.



Possible arrangements of work areas and office facilities. Rail and truck loading could be enclosed, with the center of the facility used for overhead office space.

The circular design --

- Meets today's needs and anticipates tomorrow's.
- Utilizes space to the optimum.
- Offers a modern approach to storage layout.
- Provides a compact, convenient configuration.
- Centralizes the storage operations.
- Provides better quality control.
- Provides inside loading facilities for shipment.
- Provides room to work where it is needed.
- Provides efficient and economical handling of large quantities.
- Is adaptable to large or small enterprises.
- Provides for either an individual environmental control system or a centralized system.
- Improves the total operations.

Miniaturization and Electronics Help Poultry Industry

Division researchers, in cooperation with the University of California, are using an electronic "egg" to help U.S. egg grading and packing plants reduce egg breakage losses encountered on modern high-speed mechanized grading and packing lines. A minute, electronic sensing device in the "egg" pinpoints the trouble spots in egg-processing equipment that cause these breakages, which result in severe losses to the U.S. egg industry.



*Electronic "egg" beside
a real egg.*

Of the eggs produced in the United States each year, about 5 percent is cracked or smashed. Most of these eggs are unsuitable for table use, and the rest are completely lost. These losses reduce the value of the U.S. egg crop by an estimated \$34 million annually.

The plastic egg being used to seek the cause of these breakages was developed by ARS agricultural economist John A. Hamann, mechanical engineer William L. Shupe, electrical engineer Robert M. Lake, and engineering technician Edward W. Spangler, in cooperation with food technologist A. Wade Brant of the University of California. The plastic, egg-shaped container, which is the same size as a chicken egg, houses a tiny, supersensitive device that converts mechanical energy from impacts on the shell into electrical energy which is radioed by a tiny transmitter to a remote oscilloscope receiver. Impacts show up on the receiver screen as sharp spikes and can be measured as to severity.

In laboratory studies, a measurement was made of the maximum height from which a normal egg could be dropped onto a hard surface without cracking. Then, in a similar test with the plastic egg, a measurement was made of the spike that appeared on the receiver screen. The highest point of the spike was identified as the peak at or beyond which a normal egg would crack. When the test egg was run through a component of a mechanized grading system, the image of impact signals on the screen was identified and photographed, thus determining the breakage sites. Now that their "egg" can locate trouble spots, the researchers visualize modification of mechanized egg-handling equipment to reduce breakage losses.

*Open "egg" with its
sensing device and
transmitter exposed.*



*Impact signals developed by
the oscilloscope screen.*

Interest by the industry and other researchers in the published results of the successful tests was so widespread that the USDA Office of Information was encouraged to document a test replication on film. The film, "The Electronic Egg," was produced in color, with sound, and distributed on April 1 of this year to 295 television stations throughout the United States. Since that time it has been used extensively as an educational news item.

Demonstrational Research Helps Find New Export Markets

The first export shipment of U.S. watermelons to Europe in 15 years was successfully completed after ARS researchers developed and tested packaging and transportation methods for boxed melons. The boxed and palletized melons were loaded in a ventilated van container especially designed to keep out sea water while forcing outside air through the load for cooling. The shipment went by containership to London, where it arrived in excellent condition. The Foreign Agricultural Service (FAS) assisted in promoting the melons in 24 London supermarkets, and ARS Rotterdam station personnel trained demonstrators for each store. The melons sold quickly, with several stores selling out the first day. The receiver ordered two additional van loads of melons, which also were shipped and sold successfully. Several shippers are making plans for watermelon shipments to England and to West Germany next season.



Forced air ventilated van container developed by Division researchers and used in first overseas watermelon demonstration shipment.

Our Transportation Research Branch specialists who conduct research such as that done to improve the transportation, packaging, and handling of watermelons are located in small field stations in several of the primary U.S. producing areas and in one overseas location in Rotterdam, The Netherlands. Their research in packaging and transportation often ends in the making of commercial test shipments of U.S. products to overseas markets. Small lots of products not formerly found in foreign markets are test shipped to explore the possibilities of getting these products overseas at a reasonable cost, in satisfactory packages, with acceptable service, and in good condition. These tests can play a significant supporting role in FAS market development projects. For example, winter radishes and single-strength Florida citrus juice were shipped to Europe in such tests; now a large European market has been established for these products. More often, shipping experiments involve full van containers or large break-bulk or palletized shipments in which a variety of test packages, loading patterns, load bracing, palletizing methods, or refrigeration equipment



*Demonstrator in
London supermarket
giving samples and
selling U.S. water-
melons.*

are evaluated. In all of the test shipments made, the actual marketing system is the "laboratory" for the Transportation Research Branch.

Research on packaging and transportation for overseas shipments involves transportation by truck, rail, boat, and air. Products shipped include grapes, strawberries, nectarines, peaches, artichokes, plums, citrus fruits and juices, lettuce, celery, peppers, sweet corn, celery cabbage, radishes and other winter vegetables, dried fruit, raisins, beef, live animals, poultry, animal byproducts, dried peas, lentils, beans, and grain.

Making export test shipments under commercial conditions is only part of a much larger research and development effort. Close communication is maintained between the overseas and domestic research locations in order to provide guidance for the U.S. laboratories that develop and test packages, shipping containers, transportation refrigeration systems, and loading and transportation technology. Considerable modification and pretesting may be necessary before a package design is developed to the extent that it is ready for actual overseas shipment. Similar basic research is conducted in loading patterns, load bracing, and transportation refrigeration; for example, the ventilated van container used in the watermelon shipment was rebuilt and tested in the laboratory several times before it was used to ship produce. All of the research that is related to export shipments is conducted in close cooperation with the Market Quality Research Division, ARS, and requires continuous contact with trade organizations, shippers, and receivers.

One important advantage of having an overseas location is the opportunity it provides for feedback of information on foreign marketing technology to help U.S. producers and transportation firms remain competitive in the technological race. Even more significant for U.S. firms are the savings that can be achieved in domestic transportation by applying the knowledge gained from the longer overseas test shipments. For every load of agricultural commodities shipped abroad, 10 are shipped to domestic destinations, and all shipments can benefit from better, lower cost transportation and packaging.

Improving Refrigeration Equipment Used To Transport Perishable Agricultural Products

Research to improve refrigeration systems in truck and piggyback trailers and in van containers so that they will provide more effective cooling for perishable agricultural products is an important role of the Transportation and Facilities Research Division. To obtain the basic data needed to understand what happens inside a loaded van, transportation researchers developed a standard, simulated load that would permit the testing of the loaded van and its refrigeration unit at the same time. The load, which simulates a load of place-packed fresh citrus fruit, consists of 950 corrugated fiberboard 4/5-bushel boxes, each packed with plastic balls. The packed boxes can be arranged to create different loading patterns. Electric heaters are placed in the load to simulate the heat produced in the respiration of fresh fruits and vegetables.



Researcher inserts temperature probe into a box of plastic balls. These balls are part of a simulated load of fruit in an experimental refrigerated trailer.

Prior to this research, relatively little work had been done on the problem of gaining uniformity in load cooling. In commercial practice, van bodies are not loaded when they are tested for thermal rating purposes. Further, the mechanical refrigeration units are tested separately from the van body. These two components are not rated in the environment in which they are actually used --under load, with restrictions imposed on the circulating air by shipping containers. There was, therefore, no realistic testing method for developing design performance data on which performance specifications for refrigerated trailers and van containers should be based.

During the past year, tests with the simulated load, conducted at the Division's Orlando, Florida, laboratory, revealed that there was little or no movement of the cooled air through the channels in the load, and none through the individual boxes. The tests also revealed that conventional vans in which the cooled air was discharged into the cargo area at ceiling level at high velocity (about 3,000 feet per minute) showed low static pressure (about 1 to 1 1/2 inches of water), and there was considerable turbulence in the circulating air in some parts of the load and little or no measurable movement in others.

Two ways of modifying the air circulation system in conventional refrigerated vans were developed to provide a practical, inexpensive way to make them more suitable for transit refrigeration of fresh fruits and vegetables. In one modification, the air blower was relocated from the ceiling level behind the evaporator coils at the front of the van to a position at floor level. The cooled air was distributed to the load through lengthwise channels in the ribbed floor for circulating upward through the load to the return duct at the top of the van. In the other modification, the air blower was left in its position near the ceiling, and the ceiling air duct was modified to direct the cooled air through sidewall air plenums to crosswise floor channels for circulation upward through the load to the return ducts.

With both of these modifications, greatly improved results were obtained, because the cooled air was restricted only through the depth of the load and not the length. Both tightly stacked and open-stacked loads cooled much more rapidly and uniformly.

Although the aim of this research has been to find ways to improve the transit refrigeration of perishable agricultural products, improved air circulation also will help reduce physical damage to corrugated fiberboard shipping containers and facilitate the development of techniques for unitized shipment of agricultural products. The research results indicated that much of the weakening of shipping containers--many to the point of collapse--was related to the way the cooled air was circulated around the outside of the containers, instead of through them. Under such conditions, the walls of the containers cool before the products in them. When this happens, part of the moisture exhaled into the warmer air inside the containers by the vegetables during their normal respiratory process condenses on the cool inside surfaces of the container walls. This condensed moisture is absorbed by untreated fiberboard, greatly weakening it. As a result, the weakened containers in the lower layers of the load often are partly or completely crushed. The product in these containers then is either bruised or crushed. This problem is particularly severe in tomato and lettuce shipments. The containers that come through the shipment uncrushed are still weakened to the extent that their ability to withstand additional handling in subsequent marketing channels is impaired greatly.

The research results also indicated that when the cooled air is circulated through the fiberboard shipping containers, as well as around them, the product and the containers cool at about the same rate. As a result, little or no moisture condenses on the inside surfaces of the containers to weaken them.

The methodology developed in this research project can provide the basis for a new and more realistic method for measuring the performance of refrigerated trailers and van containers in the transportation environments in which they are used. The findings also should provide the basis for future design improvements in refrigerated transportation equipment that should result in better protection for perishable agricultural products transported to domestic and world markets and potential savings of many millions of dollars to shippers, receivers, and carriers of the products.

Systems Approach Applied to Grocery Handling

Over 1,000 cases of groceries must be supplied to a large supermarket every day in order to keep its shelves stocked. These cases must be selected from their storage slots in the warehouse; taken from the storage areas to the truck loading docks, where they are accumulated for loading; loaded on the delivery truck; hauled to the store; unloaded on the store's receiving platform; taken into the store's backroom and stored; price marked; moved to the retail display shelf location; and, finally, placed on the shelf.

Instead of treating each of the handling tasks as a separate job, food distributors have begun to use a unified systems approach for handling groceries from the warehouse storage slot to the retail display shelves. The unified mobile-cart and pallet handling systems were evaluated and their costs then were compared with eight conventional methods of handling groceries. The results indicated that if all groceries in the United States were handled by the mobile-cart system instead of the most commonly used conventional method, annual food distribution costs would be reduced by an estimated \$170 million.

The mobile-cart system uses a four-wheel cart that is about 29 inches wide by 57 inches long by 72 inches high. Carts are available without a shelf, or with a shelf for more stability, and either rigid or collapsible. They may be pulled by tractors or pushed by hand.



Loaded pallet moved by pallet jack to the sales area to stock shelves.

The pallet system most commonly uses the 48- by 40-inch pallets. The pallets are moved by pallet trucks or pallet jacks. The grocery cases remain on the pallets or carts from the time they are placed there during order selection until they are removed for positioning at the retail store shelf for stocking.

The usual grocery handling method uses four-wheel trucks for order selection and transportation to the wholesaler's truck loading dock, where the cases are individually loaded on the delivery truck. At the retail stores the trucks are unloaded case by case into a temporary storage room and then transferred with a two-wheel handtruck to the shelves.

The cost for the usual grocery handling method evaluated was

\$100.70 per 1,000 cases delivered 30 miles from the warehouse. The cost comparisons between the mobile-cart and pallet systems and the usual conventional handling method showed that the pallet system and the mobile-cart system, per 1,000 cases, cost \$7.74 and \$19.23 less, respectively, than the usual, conventional method.

The cost comparison between the pallet and the mobile cart systems showed that the mobile-cart system cost \$81.47 per 1,000 cases delivered 30 miles from the warehouse; and the pallet system, \$92.96 --a difference of \$11.49 in favor of the mobile cart system. However, since empty pallets--in contrast with empty carts--occupy only a small part of the usable space in the truck, the remaining space can be used to haul products from a supplier to the warehouse on the return trip. Therefore, the cost difference between the two systems can be offset in favor of the pallet system if backhaul income of more than \$11.49 per 1,000 cases is available.

When rigid carts are used for handling groceries, there is no room in the truck for backhaul unless the carts are left at the retail store, which results in increased costs for more carts or for sending a truck to return the carts to the warehouse. When collapsible carts are used, although they do allow room for backhaul on the return trip, handling costs will be increased because of the greater initial cost of the carts and the additional labor required to collapse and erect the carts.

Based on the results of this study, availability of backhaul should be a key factor for consideration when deciding whether to adopt the pallet or the mobile-cart system.



Loaded mobile cart moved to the sales area to stock shelves.

PLANNING MARKETING FACILITIES

Problems and Objectives

Food products move through a succession of marketing facilities on their way from producers to consumers. For example, near producing areas there are facilities to assemble the products and prepare them for distribution. Near consuming areas, there are other facilities to receive these products and, with or without further preparation, move them on to retail and other outlets. Many of the facilities in use are outdated, inadequate, and costly to operate. The cost of handling food through them often is 25 percent more than would be necessary in modern and efficient facilities.

The major objectives of this research are to improve the efficiency of marketing facilities in order to hold down the costs of food marketing and provide an orderly, efficient food distribution system. The objectives are obtained by:

1. Providing technical assistance in planning improved facilities.
2. Promoting the development of improved facilities.
3. Developing criteria and technology for planning improved facilities.

Progress

FACILITIES IN URBAN AREAS



During the year, studies were made to improve the facilities for distributing food in three cities. As a result, new facilities were planned for a total of over 300 wholesale food distributors. Such studies assist local government officials, food handlers, industry groups, and civic organizations

in planning improved, modern, and efficient facilities and methods to help hold down the costs of marketing food. They focus attention on major problem areas and act as a stimulus by emphasizing the need for improvements. Work in this area during the year was as follows:

Los Angeles, California.--(See feature story and photograph, page 4.) Highlights of a study concerning the wholesale facilities and methods for distributing food in the Los Angeles area were presented on June 16 to over 600 people at a public meeting at the new Los Angeles Convention and Exhibition Center. Attending were representatives of local food firms, government agencies, trade associations, labor groups, and others interested in improving food distribution in the area. It was pointed out that 244 of the 538 wholesale food firms studied need new facilities because their present ones are either outdated, poorly designed, poorly located, or otherwise inadequate, inefficient, and costly to use. A master plan was presented for new facilities of the types and sizes needed. The plan calls for a 470-acre wholesale food distribution center, with initial construction of 53 buildings. Fifty would be designed specifically for the efficient handling of different kinds of food products, and the other three would be designed for use as a public refrigerated warehouse, an office building, and a central refrigeration plant. The initial buildings for handling food would contain over 2 million square feet of first-floor space and have a capacity for handling over 2 million tons of food annually. They would form a nucleus of facilities capable of being expanded by more than 50 percent to keep pace with the rapidly growing Los Angeles area. The central refrigeration plant would produce all of the refrigeration required and distribute it through a network of underground pipes to the wholesalers who require it. Each wholesaler would receive the kind and amount of refrigeration that he needs and would pay only for the amount that he uses. Five sites, selected as being typical of approximately 25 sites in the area that are available for construction of a food distribution center, were analyzed to illustrate factors of site selection and to estimate the total costs for providing such a center. Using brick and steel construction, the new center, excluding the refrigeration system and office building, would cost between \$63 and \$94 million, depending upon which of the five sites is involved. The centralized refrigeration system would add about \$9 million, bringing the total cost for all the facilities recommended for the handling of food to between \$72 and \$103 million. No appreciable savings in food handling costs are expected immediately as the result of the new center. In fact, these costs could increase if the cost of the site increases. Savings can be expected only after the individual food wholesalers develop their new operations and the center has more facilities and a greater volume of business, which would be expected in about 5 years.

Wilkes-Barre, Scranton, Pennsylvania.--Field work has been completed in evaluating the wholesale food distribution facilities in a seven-county area of northeastern Pennsylvania. Data were collected from about 200 wholesale food firms and are being analyzed to determine the need for overall improvement in the food handling facilities of the area. The study was initiated at the request of city officials and food industry representatives in Wilkes-Barre and was later expanded to a seven-county area which includes

the metropolitan areas of Wilkes-Barre and Scranton. The request for expansion was made by the Economic Development Council of northeastern Pennsylvania and food wholesalers in the northeastern counties area.

Altoona, Pennsylvania.--The study concerning the feasibility of a new wholesale food distribution center for Blair County, Pennsylvania, was reported in MRR 856, "Regional Wholesale Distribution Facilities for Blair County, Pennsylvania." A site of 180 acres has been acquired for the possible location of a combination wholesale distribution center for both food and nonfood products. Negotiations are underway with a large container manufacturer to locate on the site.

SPECIALIZED FACILITIES



Many kinds of specialized facilities are required to move food products from producers to consumers. Livestock slaughtering and packing plants, fruit and vegetable processing and packing plants, poultry and egg processing plants, dairy products manufacturing plants, and wholesale warehouse and distribution facilities are among the kinds of facilities needed to assemble, process, grade, package, freeze, and otherwise prepare and distribute food products in the marketing system. Research and technical assistance are provided to the food industry in implementing the most efficient combinations of individual facility designs, types, layouts, locations, operational procedures, and work methods to promote an orderly and effective system for marketing food at the lowest possible cost. Work in this area during the year was as follows:

Fruits and vegetables

Evaluating regional apple marketing facilities.--A study of the apple industries in Utah, Colorado, New Mexico, and Arizona is nearing completion. This study, conducted jointly by ARS and Farmer Cooperative Service under contract with the Four Corners Regional Commission, Farmington,

New Mexico, was designed to find ways to improve the marketing of apples produced in these four states. A draft of the study report is near completion. The report appraises the economic position of the regional apple industry in relation to the national industry, evaluates the present packing and storage facilities, and provides and illustrates the cost of new packing and storage facilities.

Poultry and eggs

Improving methods and facilities for processing ducks.--A study of a duck processing operation on Long Island was conducted in cooperation with the New York Department of Agriculture and Markets. Each function of the operation was analyzed to determine whether a more efficient method could be used. New methods were developed to help the plant salvage large quantities of product that were being lost. With adoption of the recommendations made as a result of the study, savings of nearly \$91,000 a year should be possible. A report of the study, entitled "Methods and Equipment for Processing Ducks," was published by the Division of Marketing, State of New York, Department of Agriculture and Markets.

Improving methods and facilities for processing fowl.--Plans for a fowl processing plant were developed in cooperation with the Wisconsin Department of Agriculture. The plan depicts a modern and efficient small-to-medium fowl-processing plant that meets compulsory inspection facility requirements. This plan is being adapted to a building that the firm has purchased. This facility will be a model for other Wisconsin fowl processors to follow in modernizing their facilities and operations.

Layout and operation of a duck processing plant.--Plans were developed for a plant in Cantho, South Vietnam, to process, package, and freeze 4,000 ducks per day. The operation of this plant should help to reduce the excessive price spread that exists between the prices paid to South Vietnam farmers and those paid by the consumers, and to start the country's first frozen food industry. The study was conducted at the request of the Volunteers for International Technical Assistance, Inc.

Improving methods and facilities for cutting up poultry.--A wholesaler-processor's facility in California was selected as a study plant for developing an improved broiler cut-up operation. Layouts that incorporate a cut-up machine developed recently by the Division are being prepared to improve the operations within the facility. Data and layouts developed in the study will be published to show other firms how to utilize the new equipment in their own operations, thus helping to reduce their costs.

Study of the facility and operations of a wholesale shell egg firm.--The operations and facilities used by a processor and wholesale distributor of shell eggs in California were studied to determine the potential savings to be achieved through improved handling methods and facilities. As a result of this study, the firm's per-case handling costs were reduced 48 percent.

Improving layouts for egg products plants.--A study conducted in cooperation with the Virginia Department of Agriculture and Commerce and the Consumer and Marketing Service of the U.S. Department of Agriculture to develop improved facilities for egg breaking operations was completed. As a result of this study, a new facility was planned and constructed to comply with the new Egg Products Inspection Act. This plant is the first such plant in the State of Virginia to be approved by the USDA. A study has been initiated to determine the facility requirements for another egg products plant. The facilities of a farmers' cooperative that operates in both North and South Carolina are being used in the study. Research from the above two studies will be incorporated into a report tentatively entitled "Improved Layouts for Egg Products Plants."

Disseminating research findings.--A paper was presented to the National Independent Poultry and Food Distribution Association at its annual business meeting in Kansas City, Missouri. Highlights of the Division's poultry and egg research were presented at the Institute of American Poultry Industries' Annual Fact Finding Conference, held in Kansas City, and also at the Pacific Egg and Poultry Association's annual meeting in San Diego, California. Over 9,000 members of the poultry and egg industries from all parts of the country attended these meetings.

Livestock and meat

Guidelines for establishing beef packing plants in rural areas.--An Agriculture Handbook entitled "Guidelines for Establishing Beef Packing Plants in Rural Areas" has been completed and submitted for publication. This handbook offers a practical means for making valid decisions concerning establishing beef slaughtering and packing plants in rural areas. It also identifies specific factors necessary for a successful beef slaughtering operation and demonstrates how an industrial survey can be used to determine whether a livestock producing area has potential. A companion Agriculture Information Bulletin, tentatively entitled "Beef Packing: An Industry for Rural America," has also been completed and submitted for publication. It is directed primarily to rural community leaders, chambers of commerce, municipal or regional improvement committees, and concerned citizens groups, and is intended to make such individuals and groups aware of the need to review natural resource potentials in their own immediate area. In addition, a study was undertaken at the request of marketing officials of the South Dakota State Department of Agriculture to determine the feasibility of establishing a horse slaughtering plant on Sioux tribal land in central South Dakota. The study was completed and a report was forwarded to State officials.

Dairy products

Improving dairy processing and distributing facilities.--A study was made of the operations of a milk producers' cooperative in Michigan to determine the changes needed to provide modern and efficient processing and distributing operations. The cooperative now operates two processing plants and several distribution outlets. It is estimated that the cooperative can

reduce its annual operating cost approximately \$200,000 by processing and handling the total combined volume of both plants in one. As a result of the study, the cooperative is centralizing its processing operations.

Improved layouts provided for specialized dairy products manufacturer.--A specialized dairy products manufacturer in California was provided technical guidance and recommendations, including facility and equipment layouts, in developing plans for an expanded manufacturing operation in an existing facility in a low-income residential area. The Agricultural Extension Service, University of California, Davis, California, cooperated in providing the guidance. The manufacturer has moved into the facility and has adopted the recommendations of the study. The firm has hired employees from minority groups living in the area, which should improve the general economic condition of the area.

Operations of specialized dairy products wholesaler studied.--A study of the operations of a specialized dairy products wholesale distributor in California has been completed. The study showed how an existing wholesale operation could reduce its costs if relocated to facilities in a wholesale food distribution center. The facility and the operating methods recommended as a result of the study were designed for a 50-percent increase in volume.

Grocery warehousing

Publications on improved layouts for institutional grocery warehouses.--Two manuscripts, each covering different aspects of institutional grocery warehousing, are being prepared for publication. One, a Marketing Research Report entitled "Warehouse Layouts and Equipment for Institutional Wholesale Grocers in Multiple-Occupancy Buildings in Food Distribution Centers," was cleared for publication. It described specialized grocery warehouse facilities for small firms in urban areas. A second manuscript, tentatively entitled "Institutional Warehouse Layouts and Work Methods With Four Systems for Shipping Groceries," is now being developed. It will be concerned with the costs and the advantages and disadvantages of various warehousing systems.

Studies with selected grocery firms.--Warehouse studies were carried out in cooperation with four wholesale grocery firms located in four States. One of the studies was conducted in cooperation with a grocery firm in Jackson, Mississippi. Research results indicate that the warehousing costs in its existing facilities could be reduced by more than 26 percent. Improving the warehouse layout would also reduce congestion and allow order selection to be reduced from two shifts to one. Even greater savings would be possible if new facilities were constructed. Information gathered in this study will be used to develop improved handling methods and warehouse layouts to minimize warehousing costs for other food wholesalers. The second study was conducted in cooperation with an independent grocery wholesaler in Los Angeles, California. A new, 23,000 square-foot institutional grocery warehouse was designed to permit the use of the most advanced warehousing methods practical to reduce warehousing costs. In addition, automatic data

processing equipment was recommended to help lower overall costs. The third study was conducted in cooperation with an institutional grocery wholesaler in Atlanta, Georgia. A specialized order selection system in use at the warehouse was evaluated. The findings of the study will be incorporated into a publication on facility layout and equipment for use by institutional grocery wholesalers who plan to improve their facilities. The fourth study was conducted in cooperation with a Paducah, Kentucky, independent grocery wholesaler and the University of Kentucky. As a result of this study, a layout for new facilities containing over 50,000 square feet of floorspace was designed.

TECHNICAL AND ENGINEERING STUDIES



In developing plans for improved facilities for handling food, special technical and engineering studies are conducted to solve specific problems in such areas as work methods, operating procedures, technical refrigeration facilities, materials handling systems, management guidelines, and layouts for food warehousing and processing facilities. The results are used in facility planning projects of the Division; they also are published and distributed to industry, government, and others who are interested in improving food distribution facilities. Current work in this area is as follows:

Determining requirements for central refrigeration facilities in a food distribution center for Los Angeles.--A plan was developed for a centralized refrigeration system, capable of producing 7,300 tons of refrigeration per

hour, for the proposed Los Angeles food distribution center. This system, estimated to cost about \$9 million, would distribute refrigeration through a network of underground pipes, as needed, to the various refrigerated rooms in the food center. The cost of owning and operating such a system would be about 40 percent less than the cost for each wholesaler to furnish his own individual system. A report of the study has been published in ARS 52-57, "A Master Plan for a Central Refrigeration System for the Proposed Los Angeles Food Distribution Center."

Determining costs for handling food with various types of mechanized equipment.--Costs were determined for three methods of handling food in multiple-occupancy buildings. The cost of each of the three methods was determined at nine volume levels ranging from 1,000 to 60,000 tons annually. The three handling methods studied were: (1) Pallets, using manual pallet transporters, (2) pallets, using electric pallet transporters, and (3) pallets and pallet racks, using electric forklift trucks. Findings of the study show that, at the higher volume levels, annual savings ranging from \$11,000 to \$36,000 can be realized by using pallets, three-tier pallet racks, and electric forklift trucks instead of using manual pallet transporters and stacking one pallet high. The final report on this study has been drafted and is being reviewed for publication.

Solid waste management in wholesale food distribution centers studied.--A study of solid waste management systems in use at six wholesale food distribution centers was conducted to determine the most cost-effective system(s) for particular conditions. The final report on this study has been drafted and is being reviewed for publication.

Preliminary and Followup Work in Specific Locations

Exploratory investigations are necessary before any major study is undertaken in order to determine the nature and extent of the problem involved and whether or not a study should be made, and to allocate the proper personnel and resources for conducting the study. After studies are completed, followup assistance often is necessary to help planners solve problems of implementation in order to bring about maximum benefits in food handling. Preliminary and followup work ranges across most commodity lines and includes marketing activities in both urban and producing areas. Such work was conducted during the year in the following locations:

Boston, Massachusetts.--A new \$2 million wholesale facility for the Boston Flower Exchange, a cooperative with over 240 members, was dedicated this year. This new facility, located in South Boston, was designed and constructed following a study, by this Division, which was reported in MRR-570. The Exchange formerly was located in an area being redeveloped through urban renewal.

New York, New York.--The New York Fruit Auction Corporation, occupying 16 acres, has opened in the Hunts Point area of New York City. This ultra-modern facility is capable of receiving and displaying products that arrive by truck, rail, and barge. The addition of this facility is another step

toward the completion of the vast center planned to enable New York to handle efficiently all kinds of foods. Studies by this Division in the development of the center are outlined in MRR's 389, 556, and 561.

Honolulu, Hawaii.--An \$855,000 development contract was let to a Hawaii-based firm for site preparation in the first phase of the proposed wholesale food distribution center for Honolulu. The contract calls for clearing the site, filling and grading, installing underground utilities--including power, telephone, water, and sewer lines--and paving streets and parking areas. This center is being constructed following a study and recommendations by the Division as reported in MRR 821.

Chicago, Illinois.--The Lake Calumet Food Corporation, formed to develop the Chicago Metropolitan Food Distribution Center, soon will undertake construction of a major trucking service center at the Lake Calumet site, one of the sites proposed in a study by this Division that was reported in MRR-790. This construction is expected to be the first phase in the development of the Chicago Metropolitan Food Distribution Center. The master plan for the center is being reviewed by Division specialists.

Detroit, Michigan.--A survey conducted by the city of Detroit showed that over 50 wholesale food firms are interested in locating in a new wholesale food distribution center being considered for the city. Division specialists are working with the Detroit Housing Commission and the City Plan Commission to develop plans for the center.

Huntington, West Virginia.--The Huntington Fruit and Produce Terminal, Inc., which is made up of a group of fruit and vegetable wholesalers who are being displaced by urban redevelopment in downtown Huntington, has initiated construction of a new building which is expected to be completed soon. This building, patterned after the "multiple-occupancy-building" concept recommended by the Division, will house members of the corporation.

Baltimore, Maryland.--The Governor of Maryland has informed the Greater Baltimore Consolidated Wholesale Food Market Authority that it may begin promoting land sales to food-oriented firms that would construct their own buildings in the new wholesale food distribution center for Baltimore. This center was planned after a study by the Division as reported in MRR 783.

Hartford, Connecticut.--The Connecticut Regional Market at Hartford, which was built after a study and recommendations by this Division, is being expanded by the construction of a wholesale grocery warehouse.

Knoxville, Tennessee.--The University of Tennessee has begun updating a study made by this Division in 1960 concerning improved wholesale food distribution facilities for Knoxville. Division specialists are assisting officials of the University.

Miami, Florida.--Technical assistance was provided to the Dade County Growers Cooperative Association in planning a new facility in the Miami

Terminal Market. Assistance included recommendations for the overall design of the facility, as well as its internal layout and operation.

Wichita, Kansas.--Division specialists met with representatives of the food industry and the city of Wichita concerning their requests for assistance in the planning of improved wholesale food distribution facilities for the area. A commitment was made to begin a study during the first quarter of FY 1972.

Special Research and Technical Assistance

The Division is called upon to assist in special problem areas that relate to the distribution of food in specific situations. This work may be in cooperation with private industry, contractors, or other branches of the Federal and State government. In addition, limited assistance is given to representatives of foreign governments to help them plan improved marketing facilities in their respective countries. Such assistance usually is coordinated with the State Department. Arrangements are made for foreign representatives to meet with food industry representatives in this country and to tour marketing facilities.

The following summarizes special research and technical assistance during the past year:

New produce market for Sydney, Australia.--Representatives of the Sydney Market Authority met with Division specialists in Hyattsville to consult on plans for a proposed new produce center for Sydney. Similar assistance has resulted in the completion of new wholesale food markets in Brisbane and Melbourne and plans are underway for a new market in Newcastle.

New food distribution center for Toronto, Ontario.--Representatives of the Province of Ontario met and consulted with representatives of this Division concerning plans for a new 200-acre food distribution center for Toronto. The new center will replace a smaller center that is no longer adequate for the needs of this growing city.

Guidelines for minimizing damage to food processing plants in the event of nuclear attack.--A report entitled "Facility Protection for Food Processing Plants," an industrial Civil Defense Handbook for minimizing damage in the event of nuclear attack, was published by the Department of Defense, Office of Civil Defense, in cooperation with the USDA, and released in December 1970. The handbook, which was developed under a contract administered by the Division, describes the possible effects of nuclear weapons on food processing plants and the measures that can be taken to protect them.

Publications, Speeches, and Other Reports

- A Master Plan for a Central Refrigeration System for the Proposed Los Angeles Food Distribution Center. M. D. Volz. ARS 52-57, October 1970.
(Written under contract by Food Industry Services, Washington, D. C.)
- *A New and Modern Dairy Product Distribution Facility in Niles, Michigan.
C. F. Stewart. October 1970.
- *An Evaluation of Establishing a Horse Slaughter Facility in Central South Dakota. H. R. Smalley. November 1970. (Cooperative study with South Dakota State Department of Agriculture)
- Beef Packing: An Industry for Rural America. H. R. Smalley. Agriculture Information Bulletin in process of publication.
- *Facility and Operations Study of a Dairy Product Wholesaler in Los Angeles, California. C. F. Stewart. December 1970.
- *Facility and Operation Study of a Wholesale Shell Egg Firm in Van Nuys, California. J. W. Goble. December 1970.
- Food Distribution Facilities for Oakland, California. R. K. Overheim and P. J. Hanlon. MRR-874, November 1970.
- Guidelines for Establishing Beef Packing Plants in Rural Areas. H. R. Smalley. Agriculture Handbook in process of publication.
- Improved Facilities for Wholesale Poultry Firms. C. E. Harris. Paper, annual business meeting of the National Independent Poultry and Food Distribution Association, Kansas City, Missouri, February 1971.
- Improved Urban Food Distribution Facilities for Denver, Colorado.
H. R. Smalley and T. J. Seabold. MRR-909, May 1971.
- *Improved Warehouse Design and Operations for a Wholesale Meat Facility in Los Angeles, California. J. J. Karitas and C. L. Goulston.
November 1970.
- *Layout and Operation of a Duck Processing Plant in South Vietnam.
J. W. Goble. September 1970.
- *Layout and Operation of a Fowl Processing Plant. Shiocton, Wisconsin.
J. W. Goble. September 1970. (Cooperative study with Wisconsin State Department of Agriculture)
- *Legal Basis and Contribution of Marketing Work Within the Division.
W. C. Crow. Speech to USDA Fruit and Vegetable Symposium, March 1971.
- *Not available for distribution.

- *Look Both Ways and Move Forward. W. C. Crow. Keynote address, Silver Anniversary Convention, National Association of Produce Market Managers, Raleigh, North Carolina, March 1971.
- Los Angeles Wholesale Food Distribution Facilities. E. G. Taylor. Paper presented to food wholesalers, city officials, and others interested in improving food distribution, Los Angeles, California, June 1971.
- Methods and Equipment for Processing Ducks. C. E. Harris, G. F. Amorelli, and C. M. Thrall. May 1971. (Cooperative study with New York Department of Agriculture and Markets)
- *Methods and Equipment for Processing Ducks. C. E. Harris, G. F. Amorelli, and C. M. Thrall. December 1970. (Cooperative study with New York Department of Agriculture and Markets)
- *Operations Study and Layout of a Specialized Food Processing Plant in Los Angeles, California. C. F. Stewart. October 1970.
- Planning a Wholesale Poultry Layout in a Multiple-Occupancy Building. C. E. Harris, J. W. Goble, and R. G. Kozlowski. MRR in process of publication.
- *Remodeling and Expanding a Dairy Product Processing Plant in Benton Harbor, Michigan. C. F. Stewart. May 1971.
- *The Changing Scene in Los Angeles Wholesale Food Marketing. E. G. Taylor. Article for the Packer, October 3, 1970.
- *Warehouse Design for a Wholesale Fresh Fruit and Vegetable Warehouse in Los Angeles, California. B. E. Lederer. July 1970.
- *Warehouse Evaluation and Design for a Wholesale Grocery Firm in Los Angeles, California. J. N. Morris, Jr. October 1970.
- *Warehouse Evaluation and Design of Possible New Facilities in Jackson, Mississippi. J. N. Morris, Jr. August 1970.
- *Warehouse Layout and Equipment for Institutional Wholesale Grocers in Multiple-Occupancy Buildings in Food Distribution Centers. J. N. Morris, Jr. MRR in process of publication.
- *Warehouse Layout Evaluation for a Wholesale Grocery Firm in Paducah, Kentucky. J. N. Morris, Jr. June 1970.
- *Warehouse Operations Evaluation for a Wholesale Grocery Firm in Atlanta, Georgia. J. N. Morris, Jr. April 1971.

*Not available for distribution.

*Wholesale Food Distribution Center Development in the United States.

K. H. Brasfield. Paper presented to food wholesalers, city officials, and others interested in improving food distribution, Los Angeles, California. June 1971.

Industry Meetings and Exhibits

A special exhibit concerning poultry and egg facility research was prepared and presented to participants of the Pacific Egg and Poultry Association's annual meeting in San Diego, California. J. W. Goble and J. A. Hamann. May 1971.

A special exhibit concerning poultry and egg facility research was designed, set up, and manned at the Institute of American Poultry Industries' Annual Fact Finding Conference in Kansas City, Missouri. C. E. Harris and J. W. Goble. February 1971.

*Not available for distribution.

ASSEMBLING AND STORING PEANUTS

Problems and Objectives

The production of new varieties of peanuts and the use of mechanical harvesting have reduced harvesting time to 3 weeks. Improved drying techniques and equipment are needed to keep pace with this rapid harvesting. Long, drawn-out, inefficient drying procedures can no longer be tolerated, since they create an obstacle which results in undried peanuts being left in wind-rows or stored wet. When peanuts are not dried properly, the cost of storing, shelling, and handling them increases and their market value decreases. Although the proper storage environment can be obtained by using conditioned air, the cost is excessive. To alleviate this problem, improvements are needed to increase the capacity and efficiency of peanut drying and shelling operations. Improvements in shelling and handling are also needed to reduce the current amount of physical damage to peanuts that lowers their market value, and to reduce operating costs.

The major objectives of this research are to:

1. Develop improved methods and equipment for increasing the drying rate of farmers stock peanuts, thereby increasing efficiency and lowering marketing costs.
2. Develop improved methods, equipment, and techniques for shelling peanuts, including new varieties being introduced, that will improve plant efficiency, minimize the physical damage to the product, and maintain the desired standards of appearance and quality of shelled peanuts.
3. Develop new or improved methods and equipment for efficient handling to minimize physical damage to peanuts and reduce their per-unit handling cost.
4. Develop improved methods, techniques, equipment, and facilities for storing both shelled and in-shell peanuts that will reduce storage costs and yet maintain peanut quality and provide protection from insects, molds, and rodents.

Progress

Improving Techniques and Equipment for Drying Farmers Stock Peanuts

Peanuts were dried with continuous blending and intermittent exposures to temperatures of 115° and 130° F. and an airflow rate of 40 cubic feet per minute per cubic foot of peanuts. When compared with conventional drying methods, this method increased the drying rate of peanuts by 55 to 130 percent. Although peanuts that were dried intermittently and blended had poorer milling characteristics and lower germination than those dried conventionally, this was attributed to the handling equipment rather than to the faster drying rates.

Fundamental drying studies were conducted to gain more knowledge of the mechanism of moisture movement and the relative drying rates of the different peanut components as compared with the drying rate of the entire pod. Tests indicated that low humidities during the drying operation cause more milling damage to peanuts than high temperatures.

Developing New and Improved Methods, Equipment, and Techniques for Shelling Peanuts

The loss of kernel moisture during storage of farmers stock peanuts results in monetary loss to the farmer, because this loss causes a decrease in the weight of the peanuts and an increase in split kernel outturn at shelling. Spraying peanuts with 4 to 16 gallons of water per ton, approximately 24 hours prior to shelling, proved to be an effective method of increasing the moisture content of the kernels. When the stream of peanuts was sprayed from both the top and the bottom as it was discharged from a conveyor, the water was utilized more efficiently and covered the peanuts more uniformly than when it was sprayed from only one direction. The pods were rewet on all sides by spraying the peanuts as they tumbled down an inclined belt. When the wet peanuts were stored in sealed containers, most of the moisture penetrated the hull and entered the kernel within 5 hours. The rate at which this penetration occurred was approximately the same for cracked or broken pods as for sound pods. Aerating rewet peanuts with 87° F. air for 30 minutes prior to shelling decreased hull moisture by 5.3 percentage points and kernel moisture by 0.1 percentage point. The results of shelling tests indicated that split kernel outturn was less for peanuts when the kernel moisture content was increased from 4.8 to 12 percent prior to shelling. Rewetting the peanuts to a moisture content below 11 percent increased the bald kernel outturn. However, the total bald kernel and split kernel outturns did not decrease until the peanuts to be shelled reached a moisture content of 10 percent or more. With this moisture content, the shelling efficiency increased 7.8 percent and the shelling rate decreased 20 percent. No trace of aflatoxin was found in peanuts from any of the tests. The shelled peanuts were stored in burlap bags in a dry storage room (40° to 70° F. and 5- to 35-percent relative humidity). Mold analysis revealed that, under these storage conditions, peanuts that had been rewet had no more potential for mold growth than the control lot which had not been rewet.

Florunner (a new variety) and Early Runner peanuts (a common variety), grown under contract for use in drying, storing, shelling, and handling tests at the National Peanut Research Laboratory, were studied through a complete cycle of shelling, planting, growing, harvesting, handling, drying, and shelling. These studies were made to determine the relative effects of practices used during this cycle on the seed, milling quality, and edible quality of Florunner peanuts.

Early Runner peanuts which were planted in the same field and under the same conditions as the Florunner peanuts were used as the basis for relative comparison. Two types of commercial shellers were used in the tests. Results indicated that the type of sheller used, if operated properly, had little effect on the seed quality of Florunner peanuts. Florunner peanuts had a slightly better seed quality and plant appearance

than the Early Runner peanuts. Florunner peanuts matured in 127 days and Early Runner peanuts in 131 days. The average pod size for both varieties did not change appreciably during the 3 weeks prior to harvesting. Kernels of each variety tended to become more elliptical in diameter as they matured. The maturity of the kernels within 3 weeks of harvesting had not affected germination. The field losses incurred during harvesting were less for the Florunner peanuts than for the Early Runner peanuts, primarily because Florunner peanuts grew closer to the tap root and had a stronger stem (peg) than the Early Runner. Approximately 45 percent of the Early Runner pods were cracked and approximately 12 percent of the kernels were damaged by the combine used in harvesting. Because of its thinner hull, Florunner peanuts had 5 percent more cracked pods from the combine than Early Runner peanuts, and 3 percent more kernel damage. When the peanuts were harvested at high kernel moisture contents, considerably more pod and kernel damage occurred than when they were harvested at intermediate moisture contents. Bulk storing of high-moisture peanuts for several hours before drying resulted in a critical lowering of germination, whole kernel outturn, and edible quality. Mold growth was very noticeable on these peanuts. Excessive skin slippage and kernel splitting were caused primarily by overdrying (drying below 10 percent kernel moisture). Florunner peanuts were slightly more sensitive to skin slippage than the Early Runner peanuts.

The use of bucket elevators to handle peanuts during the drying process caused most of the pods to crack, critically lowered germination, increased loose shelled kernels, decreased shelling rate and shelling efficiency, and increased mold invasion of the kernels.

Twenty percent higher shelling rates and eight percent higher shelling efficiencies were obtained for the Florunner peanuts than for the Early Runner peanuts. Measurement of grades and shelling outturns showed that the Florunner peanuts had 6.3 percent more sound mature kernels and were worth \$16.00 more per ton than the Early Runner peanuts. The Florunner peanuts also produced 15 percent more peanuts per acre. Consequently, they had approximately \$84.00 more value per acre than the Early Runner variety.

An analysis of these studies showed that Florunner peanuts were superior in quality and market value to the commonly grown Runner varieties. Their potential for eliminating the shortage of Runner-type peanuts is excellent. Gentle harvesting, drying, and handling practices are recommended for Florunner peanuts because they are more susceptible to mechanical damage than the common Early Runner variety.

A study was conducted to determine the physical, taste, and shelling properties of Chilimbaa peanuts (a variety grown in Africa). The Chilimbaa peanuts tested were larger than any of the common varieties grown in the United States. They had an excellent taste and a noticeably sweet flavor. The hull was twice as thick as the hull of the USA varieties, and, thus, offered good protection for the kernels. Because of its large kernels, 1 ton of Chilimbaa peanuts had a market value of \$10.00 more per ton than the most valuable U.S. peanuts (Florigiants). Shelling tests indicated that they could be shelled successfully with commercial-type shellers at a higher

shelling rate and efficiency, a lower split kernel outturn, and lower sheller horsepower requirements than when shelling U.S. peanuts.

Several shelling tests were conducted during the year to improve the design and operation of commercial-type shellers. Surge hoppers were designed and tested, shellers were modified, and various methods and techniques of feeding peanuts into the sheller were evaluated. Analyses of the data obtained were not completed, but observations indicated that these tests were successful in finding (a) an optimum design for surge hoppers, (b) refinements in selection of cylinder speeds and direction of cylinder rotation, and (3) effects of large columns of peanuts over the shellers.

Analyses of data from several years of tests with commercial-type shellers and the correlation of these analyses with physical property data on peanuts have shown (1) the effect of eight variables on sheller performance, (2) insight into the shelling phenomena, and (3) best sheller design and operation and sheller settings for specific commercial applications. Several variables affected the outturns, efficiencies, and shelling rates of four commercial-type shellers. These were: peanut milling quality, peanut types and varieties, sheller grate design, shelling cylinder design, distance between sheller bars and grates, methods of feeding peanuts into the sheller, grate size, and cylinder speed. Peanuts were shelled primarily by the wedging of peanuts between the sheller bars and grates. Frictional characteristics of the grates, bars, and peanut pods greatly affected the wedging of the peanuts. After the peanuts were shelled, the stirring action of the bars caused the kernels (because they are elliptical in diameter) to orient their smallest dimension to the grate openings. For production-type shelling, shellers with numerous sharp shelling edges and a large percentage of open area in the grates are best. Open-type shelling cylinders with three narrow (1/8 inch by 2 inches) sheller bars perform better than the solid-type cylinder for most commercial applications. Shellers with perforated sheet metal basket grates are best for shelling seed (or when a high shelling rate is not an important consideration).

Final selections of the best sheller design, operation, and adjustments should be based on intended use of the shelled peanuts, the type and variety of peanuts shelled, and the conditions existing at each particular shelling plant. The sheller is the primary controller of the performance of a peanut shelling plant. By using the shellers and settings recommended by the Division, the shelling plant owner can realize a saving of at least \$1.00 for each ton of peanuts shelled. A manuscript was written and submitted for publication that provides the results of some of this work on commercial-type shellers.

Small-scale studies were conducted to determine whether green harvested peanuts could be stored from 1 to 7 days at 10° and 30° F. without lowering their milling or grade quality. These studies indicated that peanuts harvested green and frozen before drying suffered extreme cell ruptures and had a very dark color inside and outside the kernel. Cell rupture was not as severe for peanuts stored at 30° F. as for those stored at 10° F., but they

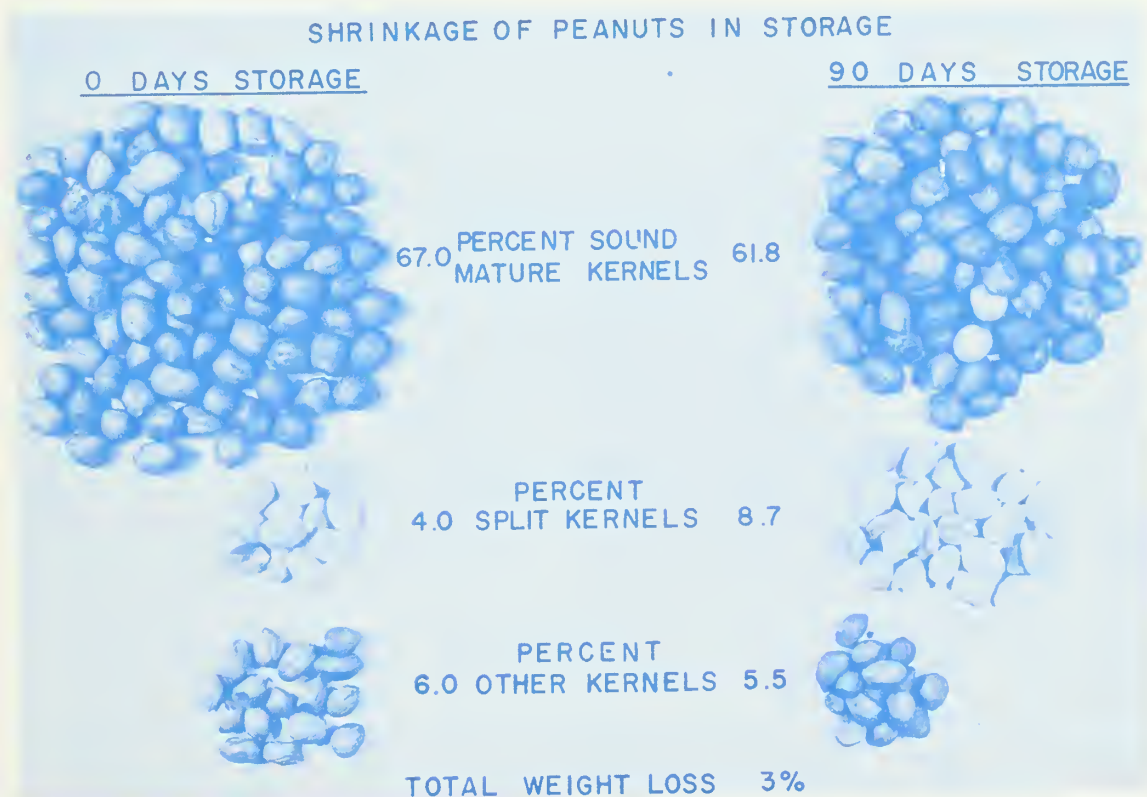
had a very yellow and blotchy color. Milling quality was not adversely affected by any of the storage treatments except when the high-moisture peanuts were exposed to thermal shock.

Small-scale studies were continued to determine the effect of peanut temperature on shelling outturn and skin slippage. Samples of Spanish-type peanuts were shelled on the official grade sheller at kernel temperatures of 35° F. and 80° F. In all tests, outturns of both split and bald kernels were higher at low temperatures. The effect of temperature and other variables on skin slippage should be investigated further.

Improving Techniques and Equipment for Handling Peanuts at Commercial Storages

Shrinkage of stored peanuts, as determined by grading factors, costs storage owners millions of dollars each year. For example, one large storage firm estimates that a drop of 1 percentage point in sound mature kernels costs them over \$1 million a year.

In cooperation with the Federal-State Inspection Service and the Southeastern Peanut Association, the Division conducted a study to determine the reduction in the percentage of peanuts in each grading factor at the end of various storage periods. (The illustration below shows the three major grading factors and the changes that occur during storage.)



The study showed an average loss of 5.3 percentage points in sound mature kernels after 90 days of storage. Much of this loss occurred as a result of the splitting of kernels which, in turn, was affected by changes in moisture content. The peanuts had an average weight loss of 3 percent during storage. Such a loss can be prevented only by better control of the storage environment. The study revealed that the moisture content of the peanuts that were stored in the conventional manner was affected by the ambient weather conditions.

The study also indicated that in order to grade peanuts out of storage at the same grade as when they were placed in storage, grading screens with openings .002 to .004 inches smaller than those presently in use are needed because of peanut shrinkage in storage. As a result of the information obtained from the study, similar studies are planned in the Virginia-Carolina and southwestern growing areas.

Improving Techniques and Equipment for Conditioning and Storing Peanuts at Commercial Storages

Tests were conducted to determine the effect of aeration on farmers stock peanuts. Ten-ton storage bins were used. Aeration fans were operated when the relative humidity of the outside air was between 45 and 75 percent. Aerated peanuts had 0.6 percent higher moisture content and 2 percent fewer split kernels than nonaerated peanuts. Peanuts near the bin walls and surface were lower in moisture content and had more split kernels than peanuts in the central portion of the bin. Results of the tests indicated that it is advantageous to aerate stored peanuts, since the market value is increased from \$2 to \$4 per ton as a result of reducing weight loss.

Farmers stock peanuts that were aerated, for 2 weeks prior to shelling, with air at 70-, 80-, and 90-percent relative humidities increased in moisture content from an initial 6 percent to 7, 10, and 14 percent, respectively. The milling quality of the aerated peanuts was better than the milling quality of the nonaerated peanuts used for control. Aerated peanuts germinated more slowly than the nonaerated peanuts, which indicated that the benefit of an increase in whole kernels which results from aeration is offset by poor germination. Thus, increasing the moisture content by aeration prior to shelling appears to be of little value to the peanut seed industry.

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CONDITIONING, STORING, AND HANDLING CEREAL AND FEED GRAINS, RICE, AND OILSEEDS

Problems and Objectives

The broad objective of the research on cereal and feed grains, rice, and oilseeds is to improve methods and procedures for conditioning, storing, and handling these crops in order to reduce costs while maintaining the quality of the product. Work in progress includes heated air drying of corn, rice, and oilseeds; the storage of moist corn, rice, and cottonseed under aeration, with and without refrigerated air; and the assessment of the damage to these products from mechanical harvesting, handling, and conditioning. Because of the sudden spread of Southern Corn Leaf Blight into the major corn producing areas in 1970, considerable effort was devoted to determining the effect of the blight on conditioning and on storage properties of infected corn.

Progress

Drying and Storing Blighted Corn

Full-scale drying tests in a continuous-flow heated air dryer showed that corn with up to 40 percent of the kernels infected by the blight fungus presented no special drying problem. The capacity and efficiency of the dryer was not affected adversely. The weight of blight-infected corn, per bushel, increased 2.7 pounds--slightly above the average for normal corn--when the corn was dried from an initial moisture content of 22.4 percent to a final moisture content of 11.2 percent. Drying reduced the germination rate of blight-infected corn less than it did with normal corn. Grade damage, ranging from an initial 6 to 7 percent in the blight-infected corn, either remained the same or was reduced slightly by drying. As indicated by breakage tests and stress crack counts, the blight-infected corn was somewhat more brittle than normal corn dried by the dryeration process, but considerably less brittle than blight-infected corn dried by conventional methods.

Laboratory drying tests conducted with corn that was harvested from susceptible and nonsusceptible plants of the same hybrid (a blend of normal and T-cytoplasm) showed that the blight-infected corn dried slightly faster than normal corn when exposed to the same drying conditions. However, the difference in drying rate was small and not significant statistically.

An important part of this study was to determine whether the drying treatment destroyed the blight in the seed. The fungus survived the moderate drying treatment (an airflow rate of 100 cubic feet per minute per bushel (c.f.m./bu.) at 180° F.). However, a more severe drying treatment (an airflow rate of 250 c.f.m./bu. at 260° F.) reduced by one-half the number of blight-infected kernels. Further tests conducted by cooperating plant pathologists indicated that corn had to be held at temperatures between 160° and 180° F. for 20 minutes to kill the fungus in the seed.

Storage tests with corn lots having various degrees of blight infection, and moisture contents ranging from 18.7 to 23.1 percent, showed that the disease did not affect adversely the storage of corn. The tests also showed that the blight fungus did not die out entirely during the storage period, even though some of the temperatures were held well below freezing for extended periods. A previous test had indicated that continuously aerated corn having a moisture content below 22 percent could be stored satisfactorily until April 1. However, when the two lots of corn with the most blight infection (one had 10 percent of the kernels infected, and the other 12 percent) were examined on this date, they still had a kernel infection of 7 and 9 percent, respectively.

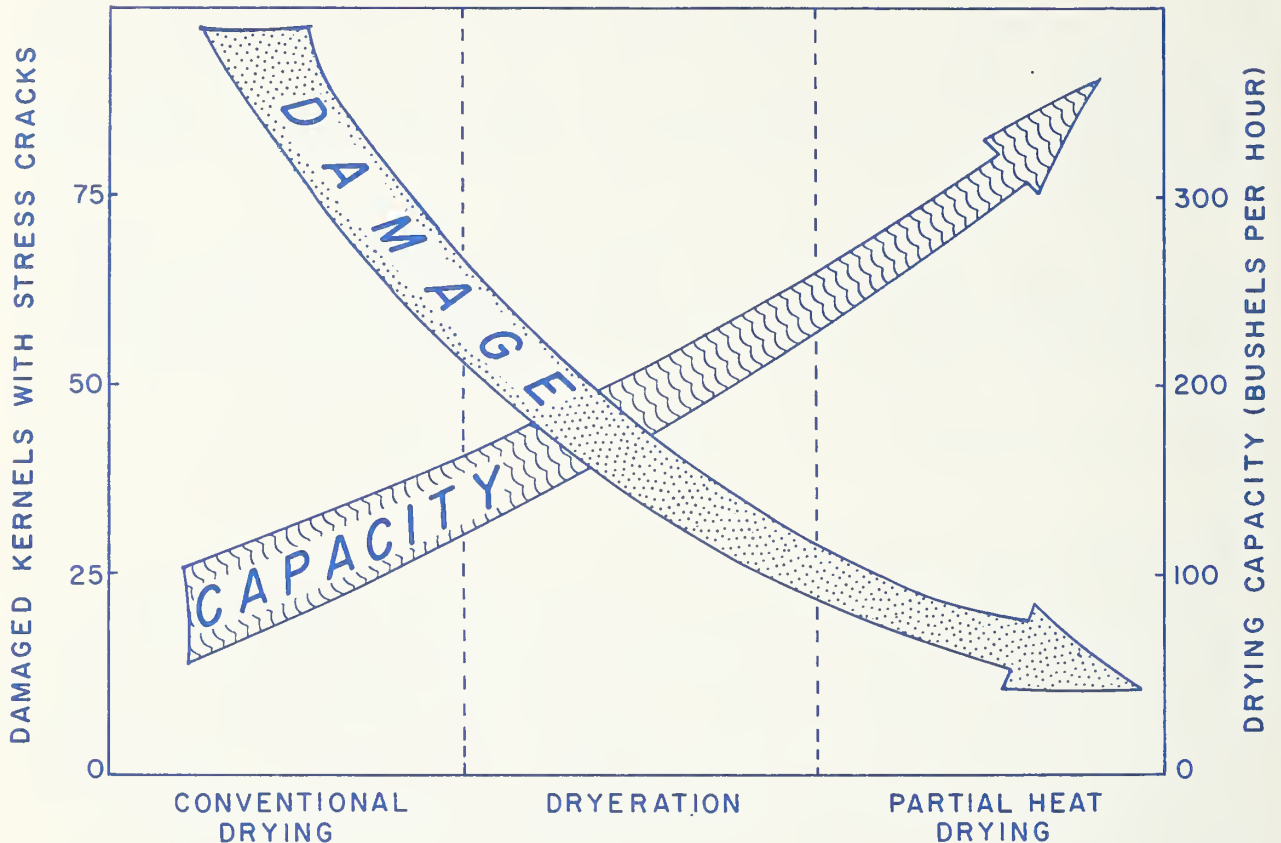
The stored corn was aerated continuously with outside air at the rate of about 0.5 c.f.m./bu. Three lots of blight-infected corn, stored at 18.7 to 21.4 percent moisture content, showed no increase in mold growth during the same storage period. In the lot of corn that was stored at 23.1 percent moisture content, the percentage of kernels infected with mold increased during the storage period from an initial 3 percent to 20 percent. This increase was attributed to the excessive moisture content of the corn rather than to the blight infection.

Drying Normal Corn, Rice, and Cottonseed

The mechanized harvesting of corn and the use of high-speed, high-temperature drying has taxed grain drying and handling equipment and facilities and caused breakage that has brought much criticism of the quality of U.S. corn, especially that offered on the world market. Sustained research has brought significant improvements in drying methods during the decade of the sixties, a period when combine-harvested, or field-shelled, corn increased from 12 percent to 67 percent of the total crop. Drying with the new "dryeration" method--a combination of heated air drying to about 16 percent moisture content, followed by tempering and aeration cooling--reduced the breakage of the dried corn by 50 percent over that resulting from the conventional continuous-flow or batch drying methods and made it possible to put twice as much corn through the dryer. A further refinement made in the dryeration method was to heat dry to only 20 percent moisture content, and then to temper, cool, and complete the drying by aeration. This procedure cut in half the breakage occurring with dryeration and increased the capacity of the expensive, heated-air drying equipment by 50 percent. The total result of this research has made possible a reduction of 75 percent in the breakage caused by the drying process and a tripling of the drying capacity of drying equipment.

Tests were made on field-shelled corn that had been dried partially by heated air and then dried completely by aeration in storage. These tests were made to improve the quality of the corn and to help reduce the load on over-burdened, heated-air drying equipment at harvesttime. First, the corn was dried from 25 percent moisture content to about 20 percent with air heated to 290° F. The corn was moved without cooling into a storage bin where it was allowed to temper a few hours. Then it was cooled slowly with aeration, which reduced the moisture content by an additional 2 percentage points. Aeration was continued through the winter months, and, by April 1, the

IMPROVED METHODS FOR DRYING CORN 1960 TO 1970



IMPROVED METHODS FOR DRYING FIELD-SHELLED CORN, DEVELOPED THROUGH SUSTAINED RESEARCH OVER A 10-YEAR PERIOD, HAVE:

- DRAMATICALLY REDUCED DAMAGE FROM HEATING AND DRYING.
- INCREASED CAPACITY OF SCARCE DRYING FACILITIES.
- LOWERED COST.

moisture content was reduced to 16 percent. This procedure produced corn that was essentially mold-free, with few stress cracks. The breakage, as indicated by a sample breakage tester, was 4.5 percent--only 2 to 3 percent--age points higher than was obtained in corn that had been dried entirely with unheated air. In addition, with the partial drying procedure, the drying capacity of the dryer was nearly three times greater than when it was operated in the conventional manner.

Efforts to incorporate the tempering process within a continuous-flow dryer were only partially successful. For a tempering time of 70 minutes, the air in one-third of the dryer was blocked in the area between the heating and cooling sections. The dried corn had more sound kernels than were obtained from conventional drying, but fewer than were obtained from the dryer-ation method--in fact, the number of sound kernels was about halfway between the two. Shorter tempering times of 10 and 30 minutes did not improve the quality of the corn. With a portion of the dryer used for tempering, the drying capacity of the dryer was reduced less than 10 percent.

Laboratory tests were conducted at three cooling airflow rates to evaluate the effect that tempering the corn before cooling it has on the amount of time required to cool it and the amount of moisture removed during cooling. Tempered corn, cooled at an airflow rate of 5 cubic feet per minute per bushel, required 30 percent less time to cool than corn that was not tempered before cooling, and had twice as much moisture removed during cooling. Thus, the amount of moisture that must be removed with heated air drying is reduced, which results in a saving in power and fuel costs for the dryer operation; a further saving in power cost results from the reduced cooling time.

Rice drying tests were made with a continuous-flow heated air dryer to determine the most effective procedure to use in multipass drying. A commercial dryer operator must often compromise between the drying capacity of the dryer and the milling yield of the rice dried. Drying at a high temperature to gain drying capacity is advantageous to the dryer operator, but not to his customer--the rice miller--if the milling yield of the rice is reduced by the high temperature. The tests conducted in FY 1971 were designed to provide information that could lead to obtaining the best possible capacity-quality relationship; that is, the highest drying temperature that can be used that will benefit both the dryer operator and the rice miller. In these tests, rice was heated to selected temperatures between 95° and 120° F. by varying the temperature of the drying air. The rice was retained in the dryer for 15 minutes during each pass. The drying rate increased 170 percent as a result of increasing the rice temperature from 95° to 120° F. However, the increase in temperature to 120° F. resulted in an average of 2.5 percent less head rice in the milling yield than when rice was dried at a lower temperature.

In laboratory-scale drying tests of cottonseed, both its moisture content when drying was started and the drying temperature had a pronounced effect on germination. Seed that had an initial moisture content of 14 percent responded essentially the same when dried at all temperatures between 110° and 140° F.; but seed that had an initial moisture content of 18 percent decreased in germination as the drying temperature increased.

The germination of the seed that had the higher initial moisture content decreased 3 percent with each 10° F. increase in drying temperature between 110° and 130° F. The most striking and unexpected result obtained from these tests was that germination was significantly higher after 6 months of storage than it was immediately after the cottonseed was dried. Immediately after drying at the 130° F. drying temperature, 25 percent of the seeds had germinated; after 6 months of storage, 70 percent of the seeds had germinated.

Aerated Storage of Moist Corn, Rice, and Cottonseed

Results from tests conducted this year in Kansas show the importance of removing harvest heat rapidly from field-shelled corn. Corn used in the tests was harvested in early September at 21 to 22 percent moisture content and at a temperature of 90° F. Three lots of the corn were placed in laboratory bins and aerated with refrigerated air. One lot was placed in an outdoor bin and aerated with natural air. One of the refrigerated bins was aerated immediately after it was filled; another, 20 hours after filling; and the other, 40 hours after filling. The corn in all of the refrigerated bins was cooled to between 35° and 40° F. in 2 days. Even though aeration was continued during the storage period, significant amounts of *Aspergillus flavus* developed in all corn except that in the first bin, in which cooling had been started immediately after filling. Aflatoxin B₁ was not present in the first bin, but was present in both of the other bins and reached 80 parts per million in corn from the middle and upper parts of the bins. Penicillium development was held in check in all of the refrigerated bins, but increased rapidly in the bin that was aerated with natural air to the extent that nearly all of the seeds were infected. Although tests with field-shelled corn in previous years indicated that cooling could be delayed 1 or 2 days without seriously affecting the storing quality of the corn, this year's test results clearly indicate that corn harvested during warm weather should be cooled immediately. The results also suggest that, at times, immediate cooling may be needed to prevent infection.

Rough rice, at an initial moisture content of 15 to 16 percent, retained its U.S. No. 1 grade throughout 180 days of storage in aerated bins. Intermittent aeration was found to be as good as continuous aeration for maintaining the quality of the rice. With intermittent aeration, the rice was aerated 4 hours daily for 180 days at a rate of 0.3 c.f.m. per hundred-weight. The moisture content of the rice dropped 1 percent with continuous aeration and 0.5 percent with intermittent aeration. Aeration during storage seemed adequate for conditioning rice having moisture contents up to 16 percent and could be used for this purpose, instead of heated air drying, when moisture levels do not exceed 16 percent.

Storage tests of cottonseed that had been infected naturally with *A. flavus* showed that substantial aflatoxin development occurred when the cottonseed was stored at moisture contents above 15 percent and at temperatures of 80° and 85° F. Seven of the twelve test lots reached levels of aflatoxin B₁ in excess of 1,000 parts per bushel within 90 days. Although the test results varied, aflatoxin development was considerably higher in the cottonseed that had been aerated than in the cottonseed that had not been aerated.

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STORING AND HANDLING BALED COTTON

Problems and Objectives

In 1969, over 6.5 million bales of cotton were carried over from the previous season. Most of this cotton was stored in warehouses in the semiarid areas of the West. Normally, the low humidity and high temperatures in this area reduce the cotton's moisture content to about 4 percent. This moisture loss during storage causes a significant reduction in bale weight, which results in a decrease in value of up to \$5 per bale. Moisture loss also adversely affects the spinning quality. Cotton that is low in moisture on arrival at the mill requires moisturizing before spinning. Our research has shown that, by humidifying cotton warehouses, bale moisture can be maintained effectively at a desirable level. Guidelines are needed for cotton warehouse humidification systems that are easily maintained and automatically hold the humidity at optimum levels when the cotton is stored in semiarid regions.

Through research, the handling of baled cotton has been improved by mechanization which has reduced labor costs for storing and removing bales from storage. However, the design and operation of equipment for unloading road trucks and for shifting lots of cotton within the warehouse still present problems in regard to utilizing the full potential of expensive equipment and maximizing worker productivity. The current method of loading road trucks at cotton gins to transport baled cotton to warehouses is costly and inefficient. Improved loading methods are needed to increase the productive time of workers and transportation equipment.

Major objectives in this area of research are to:

1. Develop equipment and operating guidelines for humidifying cotton warehouses.
2. Improve crew and equipment utilization in bale spotting, breakout operations, and road truck unloading.
3. Improve the loading of baled cotton onto road trucks at gins.

Progress

Savings Through Humidification of Stored Baled Cotton

Annual costs and benefits were studied to assess the feasibility of humidifying baled cotton storages in two geographical areas of the United States. The humidification systems and the areas assessed were: (1) Small demand systems which are required in cotton storage facilities east of a geographical line that connects Waco, Texas, and Oklahoma City, Oklahoma, and (2) large demand systems which are required in cotton storage facilities west of that line.

Small demand systems.--Small demand systems will require less than 1 pound of vaporized water per 1,000 cubic feet of compartment volume and operate less than 1,000 hours per year--virtually all of which time occurs between June and September. Whether humidification is to be used depends upon the average number of bales shipped each year during the 4-month summer period, and the average weight loss, per bale, from the early spring weight. With humidification, a warehouseman could anticipate the prevention of a maximum weight loss of 5 pounds per bale. At a market price of 25¢ per pound, a 5-pound weight loss would amount to a \$1.25 loss per bale. During the 4-month summer period, the actual average weight loss prevented through humidification was about 1.66 pounds per bale, which would amount to about one-third of \$1.25 per bale, or 42¢ per bale.

Since humidification costs 25¢ per bale, the prevention of a weight loss valued at 42¢, minus the humidifying cost of 25¢ per bale, would result in a net saving of 17¢ for each bale shipped during the summer.

East of a north-south line at the Oklahoma-Arkansas border, the maximum weight loss preventable through humidification dropped to 2.5 pounds per bale, which amounts to 63¢ per bale (one-half of \$1.25). The weight loss prevention that actually should be anticipated through humidification would be one-third the maximum preventable, 2.5 pounds per bale, or 21¢ per bale (one-third of 63¢). The humidification cost in this area is 17¢ per bale; therefore, the expected return would be 21¢ minus 17¢, or 4¢ per bale net saving.

Large demand systems.--Large demand systems in arid areas require more than 1 pound of vaporized water per 1,000 cubic feet of compartment volume and operate more than 1,000 hours per year--often longer than the 4-month summer period. The expected saving in weight through humidification ranges from a minimum of 5 pounds per bale to a maximum of 20 pounds per bale, which would result in savings ranging from \$1.25 to \$5.00 per bale at a price of 25¢ per pound of cotton. With the same average weight loss per bale as in the small demand system (one-third) and the same humidification cost (17¢ per bale), the expected return should range from about 25¢ per bale (one-third of \$1.25 = 42¢-17¢) to a maximum of \$1.50 per bale (one-third of \$5.00 = \$1.67-17¢) for the season. When cotton is stored beyond May in the area, humidification should increase the savings.

To evaluate and supervise the use of improved humidification techniques and equipment, guidelines were developed to maintain the desired humidity level in cotton storages with a minimum risk of equipment failure and over-humidification. The guidelines included a description of facilities, equipment, supervision, and maintenance needed for successful humidification. Special emphasis was placed on proper maintenance, careful supervision, and well-trained personnel.

Handling Baled Cotton in Multiple Units

Studies relating to labor and machine requirements for handling bales of cotton during conventional warehouse operations have shown the value of increasing the unit-load size of clamp trucks. However, increases in efficiency through mechanized handling have begun to diminish in magnitude and cannot be

relied upon indefinitely to keep ahead of rising overall handling costs. Without important changes in the marketing system that can reduce the reweighing, resampling, and rehandling of cotton bales within the warehouse, rising costs will continue to reduce the savings that are possible through improvements in mechanization.

Studies of the recently introduced 120-inch clamp trucks show that the greatest gain realized through its use was in the bale-storing operation. In this operation, worker productivity increased from an average of 67 bales stored per man-hour (using 90-inch clamp trucks) to 82 bales stored per man-hour. The increase in worker productivity reduced the cost of storing bales

Technician unloading bales of cotton with a clamp truck.



from approximately 91¢ per bale to 75¢ per bale. However, because the capacity of a large clamp truck is not utilized fully when unloading flat bales from road trucks, the cost improvement by using the larger clamp truck instead of the smaller clamp truck averaged only 12¢ per bale. This unexpectedly small increase was attributed to the arrangement of loaded bales on a road truck. Often the clamp truck operator removed only four bales instead of a potential eight. Because bales were placed on their sides on the top tier of the load (to serve as a load tie), the bales did not line up exactly with bales placed on their ends on the bottom tier. When standard density bales were unloaded, the unloading rate increased from 400 bales per hour with the small clamp truck to 530 bales per hour with the large clamp truck.

Studies of the use of large clamp trucks as transporters to move bales between warehouse locations showed that transporters of different sizes had nearly equal travel speeds; however, their pickup, setdown, and acceleration times followed a linear relationship that was approximately proportional to the size of the machine. A cost analysis of the bale transportation operations

showed that the marginal work done increased faster--for progressively larger unit loads--than the marginal cost increased. This relationship points out that a single transporter large enough to meet a specific work volume always showed a lower cost per bale transported than any combination of two or more smaller, less costly clamp trucks.

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HANDLING TOBACCO AT AUCTION WAREHOUSES

Problems and Objectives

Over one billion pounds of flue-cured tobacco is produced annually in the United States. This tobacco is sold at auction in tobacco warehouses that generally use outmoded methods and equipment; as a result, warehouse labor costs are extremely high. In addition, growers must wait to offer their tobacco for sale at the warehouses, thereby wasting valuable time. Because of its 200-year-old traditions, the industry has resisted change; therefore, the development and adoption of improvements in handling operations has been delayed considerably.

Recently, the reduction in the available labor force and the increase in wage rates has brought about a new interest in improving the efficiency of handling tobacco. Our research has resulted in the development of improved methods and equipment for receiving growers' tobacco at auction warehouses. However, other improvements in handling tobacco at a warehouse are needed. For example, the loading out of tobacco from a warehouse currently makes extensive use of labor and time, both of which must be reduced.

The current objectives of this research are to:

1. Implement (and modify as needed under commercial operating conditions) the experimental scheduling system designed so that growers can deliver their tobacco at a predetermined date and hour.
2. Improve the tobacco receiving operation further by designing, constructing, and testing a portable, mechanized unloading device.
3. Improve, through mechanization, the handling operations that occur before and after a sale and during loadout.
4. Determine the areas to be studied and the approaches to be used to develop a grower-to-factory system that will increase efficiency and reduce overall handling and storage costs.

Progress

Improving the Receiving of Tobacco To Reduce Handling Costs

The performance of the various operations necessary to handle a complete sale of tobacco in a 1-day shift does not permit delays or inefficiency. Through research, a scheduling system was developed for tobacco warehouses to eliminate many inefficiencies and provide for a receiving system that could operate like a well-balanced assembly line. Among its most important benefits are that the grower is not required to wait in line at the warehouse to have his truck unloaded, and management can plan ahead to assure maximum use of labor.

The scheduling system is put into effect when the grower and the warehouseman agree on the number of sheets (or pounds) of tobacco the grower will bring to the warehouse. The warehouseman places this information in a scheduling book and gives the grower a "scheduling card." The grower and the warehouseman then know the exact time and date that the grower will have his sheets of tobacco unloaded for sale. When the grower arrives at the warehouse with his tobacco at the assigned time, he presents his "scheduling card" so that headings on the tobacco sales bill and scale tickets can be filled out. This procedure minimizes delays at the scale when his tobacco is weighed.

The success of scheduling tobacco into all auction warehouses at Fuquay and Oxford, North Carolina, caused the Commissioners of Agriculture in Florida, Georgia, North Carolina, and Virginia to recommend its adoption to the Industry-Wide Flue-Cured Marketing Committee. As a result, the Committee recommended scheduling to all warehousemen and growers in the five coastal States (Florida through Virginia) for the 1971 tobacco marketing season. Likewise, the Bright Belt Warehouse Association Board of Governors voted to adopt scheduling.

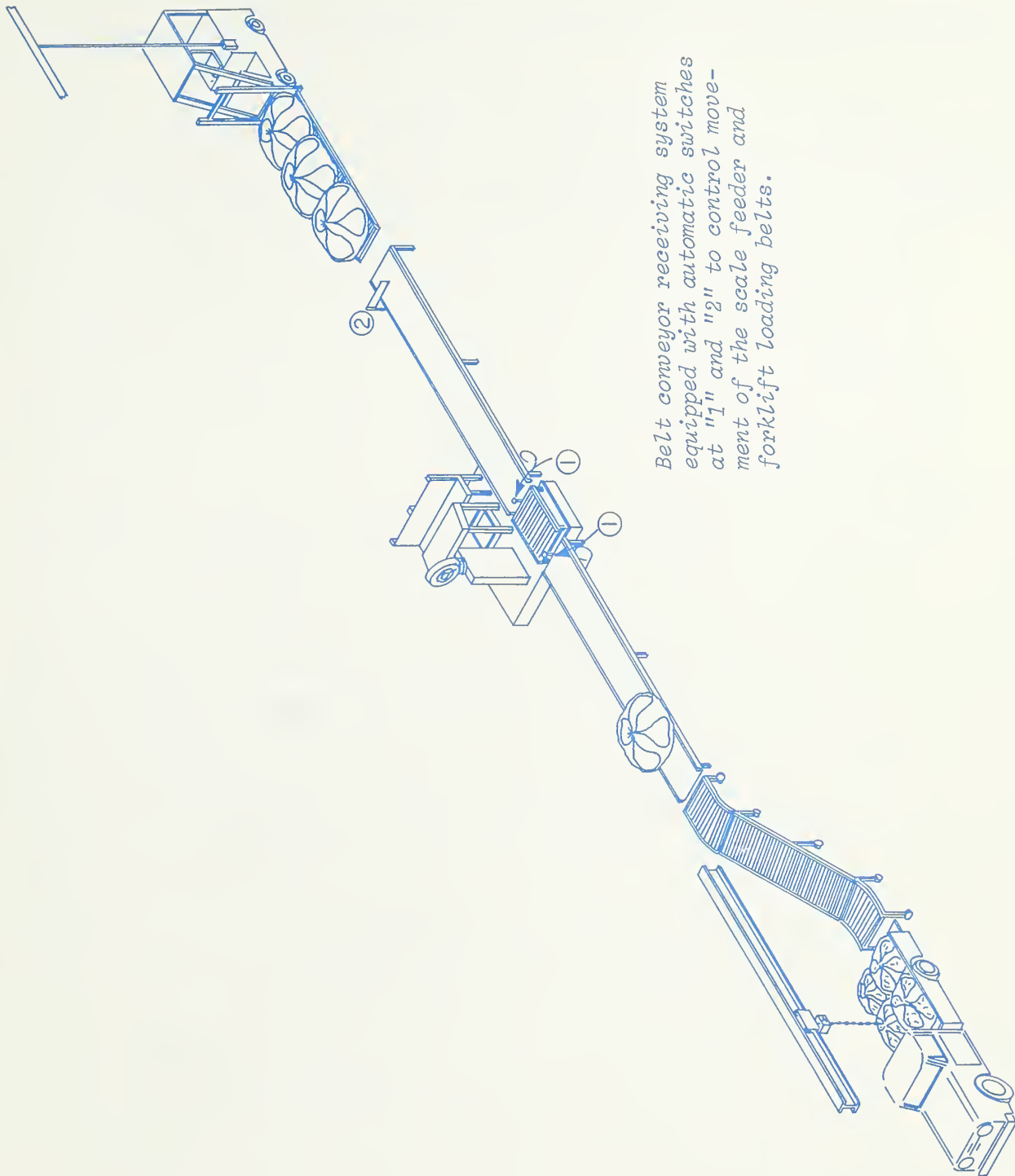
Semiautomation of the tobacco receiving operation was studied at the Carolina Tobacco Warehouse during the 1970 marketing season. The semiautomated system used there also is an integral part of a scheduling system for receiving operations.

Several changes were made in the semiautomated receiving system to increase equipment reliability and crew efficiency. The mechanical brake on the chain hoist used for unloading tobacco from a grower's truck was changed from a drum to a disc type to eliminate the need for frequent "fine" brake adjustments. The chain was modified to include a flexible attachment to the hoist to permit a crew member to remain in a central location on the truck. The height of the conveyor section behind the truck was increased to 52 inches to assure a reliable gravity flow of the sheets of tobacco between the truck and belt conveyor. Installation of electric switches on the conveyors to control the movement of tobacco onto and off the scale increased the speed of the weighing operation to five sheets a minute, which was three times faster than the 1967 rate. The occasional handling of sheets of tobacco that weigh over the 200-pound limit caused the average speed for weighing to decrease temporarily to about three sheets per minute. The efficiency of loading the sheets of tobacco onto a forklift truck was improved by installing an electric switch to control the forklift loading conveyor.

Systems Analysis of Tobacco Marketing

Since tobacco generally is ready to be marketed before market facilities open for the season, handling and temporary storage in the grower's packhouse is necessary. A limited study of approaches to minimize this cost was carried out. In a study of one grower's bulk curing facility, it was found that untied tobacco was placed in sheets directly from his bulk curing barns at a cost of about \$5 per 1,000 pounds.

At another facility, tobacco from sticks that had been machine tied was placed in sheets at a cost of about \$13 per 1,000 pounds. About one-fifth of



Belt conveyor receiving system equipped with automatic switches at "1" and "2" to control movement of the scale feeder and forklift loading belts.

the cost of "sheeting" was attributed to "picking" or grading the tobacco. Therefore, comparable costs are \$10.40 per 1,000 pounds for "sheeting" from a packhouse as compared with \$5 for "sheeting" directly from a bulk curing barn.

A study was conducted to select a tobacco package size that is compatible with the methods and equipment in use and being developed to move tobacco through the marketing system. A 42- by 28- by 28-inch box was selected for further study. This size box can hold from 150 to 250 pounds of tobacco, depending upon the moisture content of the tobacco.

ASSEMBLING, PROCESSING, AND PACKING POULTRY AND EGGS

Problems and Objectives

Processing the 5.8 million tons of poultry marketed in the United States annually has become a highly complex operation that requires increasingly costly investments in labor, equipment, and facilities, provision for which threatens the solvency of many poultry processors. Preparing the U.S. egg crop for market now involves approximately 69 billion eggs annually. The use of costly and complex grading and packing equipment is necessary for the table eggs represented in the crop. Because of the magnitude of the industry and the large investment necessary for its operation, equipment efficiency should be analyzed carefully and plants should be designed to utilize fully the costly capital investments. In addition, processors of small quantities of egg products need guidelines, because they are affected by the facility and operating requirements of the recently enacted Egg Products Inspection Act. The cost for the water used in preparing poultry and egg products for market and the cost of treating processing waste for disposal purposes have increased sharply. In some areas, conventional disposal practices--for example, using public streams--are being banned by local laws.

Major objectives in this area of research are to:

1. Reduce construction costs and increase plant capacity by developing basic guidelines for efficient plant layouts and structural designs for processing plants.
2. Decrease processing costs by more efficient labor utilization through an engineering analysis of work methods and the development of improvements to increase the efficiency of new or existing processing facilities and equipment.
3. Fully utilize technological advances in solving food processing problems and to design, construct, and test new or improved equipment that will reduce marketing costs while minimizing hazards to product quality.
4. Reduce water used in processing operations and the biochemical oxygen demand load in plant sewage through process and equipment modification.

Progress

Improving Facilities

Facility design for eggs and egg products.--Guidelines for an efficient egg grading and packing plant layout were published. The report includes the structural specifications for an egg grading and packing

facility with a production capacity ranging from 1,000 to 5,000 cases of eggs per week. It provides detailed design drawings of a facility that readily permit expansion, and illustrates and explains simplified engineering techniques for precise calculation of space requirements in the storage and processing areas so that plant operators can adjust dimensions to fit their specific situation. Provision is made for operators who wish to include processing facilities for egg products (limited to liquid or frozen whole eggs) by including a layout for an efficient egg products processing room that meets the requirements of the Egg Products Inspection Act.

Improving Equipment

Mechanizing broiler cut-up equipment.--Laboratory and field tests were completed on experimental equipment for complete mechanization of the broiler cut-up operation. Field tests were conducted in commercial plants under normal operating conditions to prove the practicality of the equipment and to determine its production potential. In each test, fully mechanized cutting proved to be more advantageous than conventional cutting.

*Fully mechanized
broiler cutting
equipment.*



Labor requirements decreased by 50 percent, cutting accuracy increased, and the hazards to worker safety decreased. Commercial application of the design principle was adopted quickly by the equipment industry. Within 6 months after this experimental equipment was tested and given public exposure, an estimated 40 commercial units had been manufactured and put into regular use. (The patentable features are in the public patent process.) One plant operator recently stated "We are currently cutting up 44 birds per minute with two machines, and we are getting a more uniform cut than we were by hand."

Commercial models of the equipment range in price from \$3,000 to \$7,000, depending upon the complexity of the cutting requirements of the plant operator.



*Conventional
broiler cutting
equipment.*

If only 10 percent of the broiler crop now being cut up at the processing plant (approximately 42 million birds per year) were cut up by this equipment, the estimated savings should exceed \$35 million annually. The research that led to the development of the equipment cost about \$150,000.

Mechanized coop-handling system for poultry.--Field studies were completed and evaluated on the use of conventional manual methods and equipment for loading and unloading coops of live chickens as compared with the use of powered lift trucks. The results of the unloading phase of this study will be used as a basis for evaluating the improvements--reduced bruising damage and reduced labor requirements--that will be derived from use of the mechanized coop-handling system now being completed.

An empty-coop restacker was designed and a prototype was constructed. (This is a companion unit to the unstacker, reported last year, which is a component of a mechanized coop-handling system.) The restacker receives coops one at a time and stacks them vertically to the desired height. After the coops have been emptied on the unloading dock and restacked mechanically, they are conveyed to a holding conveyor where they are held until returned to the live-haul trucks from which they were unloaded. The coop restacker could replace the two workers who normally are necessary to handle the empty coops. With an assumed 30 plants using the coop restacker, potential annual savings of about \$500,000 can be realized the first year. The additional use of the unstacking component of the mechanized handling system should result in estimated annual savings of another \$1.5 million from reduced bruising and reduced labor requirements, for a total saving of approximately \$2 million annually. The cost of developing the system is estimated at \$150,000.

Poultry slaughtering and defeathering equipment.--Research on poultry slaughtering and defeathering began by observing the methods, equipment, and layout used in 18 processing plants in North Carolina,

Georgia, Alabama, Mississippi, Louisiana, and Texas. Particular consideration was given to the methods used to remove blood from the killing areas.

All plants visited indicated problems with blood removal and cleanup. Their facilities for removing blood varied from hand trucking the blood in barrels to removing it by means of the yet unperfected pneumatic blood collection systems. Some plants allowed the blood to flow into the sewage from processing. Based on these observations, an effective system was designed to remove blood from the slaughtering area mechanically without overloading the sewer system. The system includes a pipeline from the slaughtering area to a 500-gallon collection tank equipped with a high-volume vacuum

A pneumatic blood collection system for poultry processing plant.



pump that removes accumulated blood at predetermined intervals. Sensing probes in the tank are used to shut off the system before the tank overflows. Compressed air is used to empty the tank. The intake valve closes and the discharge valve opens as compressed air is applied to the tank. After the tank is emptied, a CIP (clean-in-place) system sprays the tank interior with water and discharges it. The system, currently undergoing commercial tests, collects 450 gallons of blood during the 15-minute cycle (includes collecting, discharging, and cleaning). With this method of blood handling, an anticipated 75 percent reduction in daily cleanup time (approximately 6 man-hours) is expected. In addition, the system will reduce

greatly the biochemical oxygen demand load currently discharged from the process. This principle seems adaptable to removing other types of waste (for example, feathers and viscera) and will be studied.

Observations were made of various makes and models of machines that kill birds mechanically. Almost all of the machines had some flaw that adversely affected the final product. The most common flaw found was that the bleeding cut they made was too deep, which caused excessive loss of heads during defeathering, as well as violent death struggle. Generally, electric stunners were used, prior to the bleeding cut, to control struggle. Not one of the mechanical killing operations was as efficient as a good manual operation. An urgent need clearly exists for further research to develop an efficient mechanical killing operation.

Modifying poultry processing equipment to conserve water.--The experimental bird washer constructed and tested with inconclusive results last year was modified by lengthening the spray tunnel and providing greater flexibility in spray nozzle position. After successfully testing the experimental laboratory unit, the machine's design principles were incorporated in a commercial washer in a local processing plant. Tests are currently underway to determine the effectiveness of the improvements (ability to wash birds



The interior of the modified commercial bird washer in a poultry processing plant.

thoroughly with a minimum amount of water) at a washer capacity of 80 birds per minute. Auxiliary equipment and instruments include: Booster pump, pressure regulator valve, flow meter, pressure gage, and water screen. Preliminary results indicate that, under optimum conditions, the unit will reduce the plant's water use by about 50 percent. This reduction amounts to 20,000 fewer gallons of water used per day by an average poultry processing plant. Although the cost saving of the water is usually small, the reduction in the sewage treatment cost will bring about a significant saving.

The washer's effectiveness will be determined ultimately by its cleaning efficiency; that is, its ability to reduce the microbial population count (to be determined by cooperating researchers at the Richard B. Russell Agricultural Research Center, Athens, Georgia).

A second phase of this research which was initiated during the report year also involves reduction of water use and pollution. A fat and solids separation tank was designed and constructed as the first unit of an experimental apparatus to remove soluble and insoluble material from waste water so that the water can be recycled for other plant uses. The fat and solids separation tank is a closed system with a circulating pump and flow meter built into the line. The tank has adjustable baffles that can be arranged to create eddies and swirls as the water is pumped through. With each setting of the baffles and with a specified rate of water flow, a measured amount of chicken fat is injected into the system through an intake valve. Flow rate readings and water samples are taken before and after each cycle.

The tank removes approximately 50 percent of the fat during the first cycle--with decreasing amounts in successive cycles--leaving about 10 percent after five cycles. Plans are being formulated to develop continuous skimming and removal equipment for a prototype system. After laboratory testing, the system will be moved into a processing plant where carcass-chiller water and final wash water will be cycled through it for commercial testing. If the water from these operations can be recycled on a commercial scale, each U.S. poultry processing plant can conserve about 70,000 gallons of water daily, and its sewage treatment cost can be reduced correspondingly.

Improving turkey boning equipment.--The University of California, cooperator with the Division in research to improve the yield of prime meat cuts when boning turkeys, published the results of the studies in Poultry Science. The studies showed that the use of the improved, mechanized boning line resulted in an increase of 2 percent in the yield of prime meat cuts. They also showed a significant correlation between the body conformation of the turkeys (related to strain, age, and sex) and the yield of boned meat. The potential increase in prime cuts through use of the improved equipment and a guide for selecting the meatiest type of bird for further processing should result in approximately \$3 million annual savings. The research cost \$100,000.

A similar study involving the boning of culled laying fowl was initiated during the report year. Manual boning operations were evaluated as to labor requirements through application of engineering work measurement techniques. Two components of an experimental mechanized boning system (a drumstick and wing cutter, and a skin peeler) were constructed and tested independently to determine their effectiveness as a part of the mechanized line. Preliminary evaluation indicates that the labor saving in these preparatory operations will contribute significantly to reducing the labor requirements for boning carcass and thigh meat (the sources of prime cuts of boned fowl meat.)

Electronic device for detecting mechanized equipment design features that cause egg breakage.--(See feature story on page 8.) After numerous modifications and laboratory tests, the plastic, egg-shaped shock-sensing device developed last year for recording areas in machine handling where impacts cause egg breakage was used in commercial plant tests. Problems were encountered in recording signals from the transmitter system. When the antenna of the transmitter approached a metal surface, its output signal changed. Also, the motors, relays, and switches used in the grading line sent out signals that were picked up by the receiving antenna. Differentiating between spurious signals and those from the test-egg impact signals was very difficult. Fortunately, most of the egg grading and packing systems use a number of non-metallic materials in some of the critical impact areas which make the detection of breakage level shocks possible. The test results showed that severe impact shocks occurred (1) when eggs were loaded onto the machine conveyor belt, (2) when they reached the weighing station, (3) when they were loaded into cartons at the cartoning station, and also (4) when they rolled against other eggs and/or guide bars in the area. Application of these findings to modification of machine design, operation, and maintenance should assist in reducing the estimated \$34 million loss that the industry suffers because of machine-induced egg breakage.

Improving Work Methods

Methods and equipment for eviscerating turkeys.--Studies were completed to evaluate methods and equipment used for eviscerating turkeys, and to establish guidelines for crew balance and for efficient production rates and work station layouts. The labor requirements and equipment necessary for performance of the work required was evaluated through application of the motion-time-measurement technique. The findings were confirmed by motion picture photography. The time values establish precise standards, once unavailable to the management, for performance of the various procedures on the eviscerating line. The influence of line speed, crew balance, and bird class on each worker's productivity is projected in table format as a guide that plant management can use to select the most desirable number of hen and tom turkeys for specified line speeds when the plant is using conventional processing methods.

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W. L. Shupe. Silent film in black and white. (Available for loan from
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ASSEMBLING AND SLAUGHTERING LIVESTOCK; AND ASSEMBLING, STORING, AND PROCESSING MEAT AND DAIRY PRODUCTS

Problems and Objectives

Over one-half of the agricultural income in the United States comes from the animal and animal products industry. A great part of this huge industry is operating in obsolete facilities and using costly manual methods. Engineering research techniques have been developed to improve work methods, devices, operating procedures, equipment--including automated systems, and facility layouts. Application of these techniques in the industry could reduce marketing costs by as much as \$50 million per year.

Major objectives of this research are to:

1. Minimize facility costs and increase productivity by developing efficient layouts for livestock markets, meat plants, and dairy product plants.
2. Reduce marketing costs by developing improved operating procedures and means for more efficient utilization of labor.
3. Reduce marketing costs by designing, constructing, and testing new or improved equipment and devices to replace expensive manual methods.
4. Minimize operating costs by developing techniques for adapting automated procedures to livestock, meat, and dairy marketing.
5. Reduce pollution by developing more efficient cleaning procedures and waste disposal systems for livestock markets, meat plants, and dairy products plants.

Progress

Livestock

Improving computer handling of sales data in livestock markets.--The purpose of this research is to increase the efficiency of handling sales data in livestock auction markets by converting the previously developed machine language program to a procedure-oriented language program. The language selected was COBOL (Common Business Oriented Language). The work was done under a cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Missouri.

In most of the Nation's 1,700 livestock auction markets, sales data are recorded manually in the auction booth and then transferred to the market office where a clerical staff prepares the necessary records and accounts. Excessive clerical labor costs are common, and errors occur, which are costly. In 1969, there were nearly 30 million cattle, 12 million hogs, and 1.5 million

sheep sold in auction markets in this country. Total labor costs for this vast operation were estimated at about \$40 million. Of this cost, about \$8 million, or 20 percent, were clerical costs. To solve the problem of clerical costs, a computer system was developed which has been in daily use in a live-stock auction market in Missouri for more than 2 years. The original machine language program limited the system to the individual market for which it was designed and, therefore, its use was considered too expensive for the smaller markets where sales are held only 1 or 2 days per week.

To correct this limitation, the original machine language was converted to COBOL. The basic components of the system are an IBM 1130 computer, a card reader, and a list printer. The computer calculates the total price and deducts all applicable charges (for example, for commissions, insurance, feed, and trucking), and makes appropriate entries of each transaction on buyers' invoices, sellers' accounts, and the market's record. This system is flexible enough for use with a wide variety of computer equipment and can receive and transmit data from several locations. It provides for use of remote input-output devices and leased wire services and is fully capable of handling sales data from several livestock markets within a radius of about 100 miles of the computer installation. The COBOL system also can be used by banks and other business enterprises so that its use allows a livestock market in a remote location to use the equipment in cooperation with other markets and other types of businesses.

The major advantages of the COBOL system are that it minimizes the possibility of errors in computations and in the preparation of records and accounts, reduces the incidence of miscounting or "losing" animals in the marketing process, speeds up payment for animals following their sale, and provides a permanent record of all sales transactions. Commercial tests under actual operating conditions indicate that this system can reduce clerical costs by as much as 50 percent.

A report covering the results of this research was in draft form at the end of the report year.

Improving methods, equipment, and facilities for handling waste material from livestock markets and commercial feedlots.--The purpose of this research is to determine the most efficient methods and equipment for removing and disposing of waste materials from livestock pens, to find ways to reduce excessive water use, and to minimize pollution. During the report year, 16 livestock markets were visited, and detailed studies were made of one or more of the problem areas.

Studies were made of four terminal stockyards where waste materials were dehydrated and sold as a specialty fertilizer through nurseries, garden and lawn supply centers, and hardware stores. The cost of drying the manure ranged from 1.6 to 2.2 cents per pound of dried material. In some instances, the markets were able to make a small profit from the sale. If dehydration of the material permits its sale with no significant loss to the stockyard, the use of this method may provide the least expensive method for its disposal.



BUYER/SELLER WINDOW



CHECK-IN AREA



COMPUTER



CATTLE SALES RING



HOG SALES RING

Essential areas of a livestock auction market. Electronic computer to process sales data is located in the office. Data flow, shown by solid lines, is by pneumatic tube. Punched cards are used to put sales data into computer. Invoices, checks, and statements come from the computer and are given to customers through the buyer/seller window, as shown by dashed line.

A serious problem at the dehydrator plants is the control of dust and odor. In addition to creating an unpleasant situation for the area in which it is located, the plant operations create an unhealthy and unpleasant atmosphere for the workers. The dust and odor from these plants must be eliminated or reduced if dehydration is to continue as a usable method of waste disposal, or dehydrator plants will be forced to close.

Merchandising of dried or composted animal manures as specialty fertilizers is regulated by individual States. The States can impose stringent limitations on the guarantees offered with the material being sold and on its stated content analysis. The amount of dirt or sand in the final product limits its salability, of course.

Research is underway on various types of front-end loaders used by most livestock markets to clean pens. Cleaning efficiency and operating costs are of major concern in these studies.

Some data have been collected to provide background information for designing a facility for adequately cleaning and disinfecting livestock trucks. Uncleaned or improperly cleaned livestock trucks may spread disease organisms and noxious weeds.

Work was started late in the report year to determine water utilization in livestock markets. As an example of the problem, many water hydrants run continuously, which wastes water and increases the water costs.

Solid waste was being stockpiled at most of the markets studied during the year. Drainage, seepage, and storm-water runoff are a major source of pollution. A detailed study of pollution control in the markets is being planned.

Meat

Improving methods and equipment for handling and processing "hot" pork products.--This research was undertaken for the purpose of investigating new processes and equipment for handling pork and pork products. A system of processing pork while it is "hot," or prior to the traditional 24-hour chill, offers possibilities of tremendous savings to the meat industry by reducing chill cooler space requirements, labor costs (since the meat would be handled fewer times), and transportation costs.

During the report year, the computer analysis of the data obtained during the commercial testing phase of the research on "hot" processing of pork products was completed. This phase of the research was done by the Nebraska Agricultural Experiment Station under a cooperative agreement. The computerized data included (1) microbial counts of fresh and cured hams and loins, (2) color stability studies covering all major cuts, (3) chemical data on fresh and cured hams and sausage products, and (4) temperature, humidity, air velocity, and other data concerned with the mechanical performance of the continuous-flow chill cabinet. A draft of the final report is expected soon from the cooperator.

Improving methods, equipment, and facilities for plants that render inedible animal byproducts.--The purpose of this research is to determine the equipment, facilities, operating procedures, or management practices that are involved in the transmission of salmonella contamination from the raw products area of a rendering plant to the finished products area. The rendering process adequately controls salmonella; however, studies show that the rendered product frequently is recontaminated prior to leaving the plant.

Cooperative work with the Animal Health Division, Agricultural Research Service, aimed at controlling salmonella infestation in animal byproduct rendering plants, was continued during the year. Through this intra-agency cooperation, the knowledge of engineers and microbiologists is combined to assist in the collection and analysis of data and should lead to the designing of a plant that would be salmonella-free. Computer analyses were made of the field studies in six cooperating Oklahoma rendering plants. The field studies used environmental data for evaluating total bacterial count, causes and effects of contamination in within-plant rendering operations, and relationships of environmental factors to product contamination. Members of the two Divisions held several consultations during the year on methods of handling the data, which will be processed at the Data Computing Center, Oklahoma State University, Stillwater, Oklahoma. Several printouts of the research data were obtained and checked for accuracy. Within-plant correlations and overall plant correlations were run on all data to determine the relationships of the various readings. At the end of the report year, these data were being analyzed and evaluated by an ARS statistician.

Improving methods, equipment, and facilities for meat packing plant operations.--The objectives of this research are to improve the efficiency of meat packing plant operations and to develop improved handling and processing methods for meat from all species of livestock.

The research to improve work methods, equipment, and facilities for meat packing plants of several sizes was continued during the report year. Case studies of individual plants are about 90 percent completed. Data on eight packing plants were collected, tabulated, and summarized during the year. The data summary showed the large number of variables involved in accurately comparing and evaluating the efficiency of cattle kill-floor arrangements in meat packing plants. The kill rate ranged from 14 to 48 cattle per hour. Kill-floor productivity with the on-the-rail method ranged from 0.92 to 1.55 cattle per man-hour. It was quite obvious that productivity increased as the volume of carcasses increased. The data also showed that the use of hide pulling or stripping machines reduced by about 12 percent the total elapsed skinning time per carcass.

Preliminary results from this research indicate that most plants using the on-the-rail system are operating well below the capacity of their particular system. With proper job allocation and production line balance, plant operating costs should be reduced as much as 30 percent. In plants where case studies have been made, consultations with managers concerning the results of the studies have enabled most of them to increase their production rates substantially. At one plant studied last year, the manager was able to increase his kill rate from 30 cattle per hour to 45 cattle per hour by adding two workers to a 17-man crew and reallocating job elements to the resulting 19-man crew.

Developing layouts and operating criteria for small, locker-type meat packing plants.--Research on developing layouts and operating criteria for small, locker-type meat packing plants was continued during the fiscal year. Proper and efficient layout and design of small-scale rural livestock slaughtering and processing plants to meet the requirements of the Wholesome Meat Act of 1967 are vital to the survival of this industry. In many instances, improper design caused considerable losses to the industry, because costly repairs and remodeling were necessary before these small plants could meet inspection requirements. For example, one food firm had to spend \$5,000 after completion of its new plant to correct the improper design of a kill floor so that the plant could meet inspection requirements. Efficient layouts also can reduce operating costs substantially.

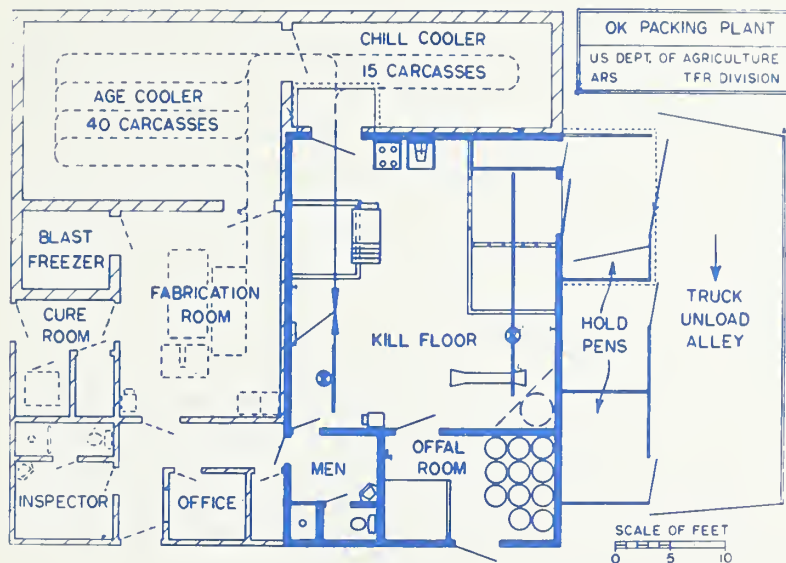
Forty-five small, locker-type meat packing plants in Oklahoma and Texas were visited to obtain background data and to conduct case studies of their operating characteristics. Some of these plants are operated in conjunction with another business, such as a grocery store; others are independent businesses. Their volume ranged from 5 head of cattle per week to more than 100 head. Most of the facilities were constructed 30 to 40 years ago. In most cases, these facilities cannot pass the construction and sanitation requirements of the Wholesome Meat Act of 1967, so their operators are forced to remodel their present facilities, construct new plants, or go out of business.

Field investigations showed the following conditions existing in these plants: Plant areas were polluted by open ditches used to dispose of viscera and blood; cracked walls and floors and rusty equipment made adequate cleaning impossible; sanitation was poor because insects and rodents had easy access to the facilities; equipment could not be sterilized because of an inadequate supply of hot water; and space was inadequate for efficient handling and proper sanitation.

Example of an inadequate facility used for a locker-type meat packing plant.



During the report year, the Stillwater, Oklahoma, office, in cooperation with the Oklahoma Meat Inspection Office, gave assistance to 10 operators who needed to remodel their old plants or build new ones. These plant operators were provided with layouts for handling, slaughtering, fabricating, and



An efficient layout for a locker-type meat packing plant. The layout provides for adequate space for the handling operations, an arrangement of plant components for minimum operating costs, and an adequate sanitation program.

processing that fit their desired plant volume and provided for reasonable expansion and equipment requirements. They were provided also with information on construction costs. Application of Division research has resulted in the reduction of pollution through use of adequate waste disposal systems, the elimination of breeding areas for disease carriers, provision for adequate sanitation programs, and the reduction of operating costs through efficient layouts and handling procedures. Furthermore, the use of knowledge gained through this research has made it possible to save an essential rural industry and to preserve jobs for local workers.

Example of a modern facility used for a locker-type meat packing plant. This type of facility is replacing the dilapidated structures previously used.



Dairy

Increasing efficiency through automation in manufactured dairy products plants.--During the report year, visits were made to eight plants that manufacture dry milk products. Data were collected on the equipment, operating procedures, and layouts in these plants.

The milk processing capacity of the plants studied ranged from 72,000 gallons per day to 140,000 gallons per day, with an average of 110,000 gallons per day. The plants employed from 20 to 60 workers, with an average of 40. Some of the plants were newly constructed; others have been in operation for various periods of time up to 40 years. Many of the older processing plants are being expanded; therefore, information on various types of layouts and operating methods is needed by these plants so that they may expand their operations efficiently. Studies on improved layouts and operating procedures were initiated to meet the needs of these plants.

Data on layout of the receiving area, truck unloading procedures, and truck cleaning procedures were collected in both dry milk processing plants and fluid milk plants. In the plants studied, the time required to unload ranged from 8 to 50 minutes; and to clean trucks, from 15 to 30 minutes--depending upon operating procedures, layout of the area, and size of the trucks. Milk arriving at the plant was unloaded at a rate ranging from 6,000 gallons per hour to 20,000 gallons per hour. The storage capacity of the plants ranged from 75,000 to 160,000 gallons.

At the end of the report year, a manuscript dealing with the engineering principles involved in product flow, personnel flow, and dry goods flow in a dry milk products plant was in draft form. Tabulation and evaluation of data on different types of receiving areas are underway.

Increasing efficiency through automation in multipurpose fluid milk plants.--During the past year, major effort was devoted to these critical questions: At what point is milk processing equipment "clean"? Are there other chemicals which could be used in cleaning that are less abrasive and less damaging to the equipment than those currently used? Is it really essential to heat the cleaning solutions to conventionally used temperatures in order to clean the equipment adequately?

The answers to these questions will allow cleaning, the most costly operation in a fluid milk plant, to be reprogramed to minimize time and labor, to reduce the amount of hot water used on cold metal surfaces, and to permit the use of milder and less expensive chemicals for cleaning.

A test was developed previously to determine the amount of milk soil on a stainless steel surface, based on the amount of calcium on the surface. One normal hydrochloric acid (1.0 HCl) was used as the solvent to remove the milk soil. The hydrochloric acid was effective in removing the milk soil, but tended to corrode the surface of the stainless steel. This past year, experiments were conducted to determine the effectiveness of three other acids--phosphoric, lactic, and nitric--in two concentrations, 1.0 N and 0.1 N, to clean equipment. Nitric acid in an 0.1 N concentration proved to

be as effective as hydrochloric acid, the conventionally used solvent, in removing milk residue from a stainless steel surface; it is also less expensive and causes much less corrosion to stainless steel. Phosphoric acid and lactic acid appeared to offer no advantage over the use of hydrochloric acid.

Other experiments were conducted to determine the rate at which rinse water removed milk residue from a stainless steel plate that was used to simulate an actual piece of milk processing equipment. As the rinse water removes milk from the plate, the ionic content of the water is increased because of the ions in the milk. The amount of ions in the rinse water can be measured by electrical conductivity. The variations in the electrical conductivity of the water-milk mixture leaving the plate indicate the amount of milk being removed from the plate. For the conditions studied (1.5 and 3.0 gallons of water per minute, 60° and 90° slope of the plate from the horizontal, and 95° and 125° F.), the mean time for removal of the milk residue was 14.4 seconds. The milk residue was removed faster at the higher flow rate (3.0 gallons of water per minute), but the amount of milk removed was the same as with the slower flow rate (1.5 gallons of water per minute). When the plate was sloped 60° from the horizontal, it was rinsed more thoroughly than when sloped 90° from the horizontal. At a temperature of 95° F., more milk was removed but at a slower rate than at a temperature of 125° F. The results of the experiment indicated that approximately 75 percent of the milk placed on the plate was removed by rinsing with water.

During a rinse cycle, the temperature of the water-milk mixture varies, depending upon the type, quantity, and temperature of the equipment being cleaned. Since temperature affects conductivity, the changes in temperature of the water-milk mixture cause changes in the electrical resistance of the mixture. Experiments were conducted to determine the changes in electrical resistance of water-milk mixtures and their relationship to changes in the temperature of the water-milk mixture and the concentration of milk solids. To measure accurately the rate at which residue could be removed during the rinse cycle, the temperature of the solution, as a variable, had to be eliminated. The information on changes in electrical resistance was used to design a thermistor-based electrical circuit which would eliminate temperature as a variable by compensating for temperature changes between 68° and 176° F. in the water-milk solution. Once temperature was eliminated as a variable, the rate at which milk residue was removed from the plate by rinsing could be measured definitively.

During the cleaning cycle, a detergent is recirculated through the milk processing line. As the milk residue is dispersed in the cleaning solution, it is recirculated, along with the cleaning solution, through the processing line. To determine the rate at which this solution resoiled the plates, both clean and soiled stainless steel plates were rinsed for 5 minutes with cleaning solutions which contained, respectively, 0.1 percent, 1 percent, and 10 percent milk. Preliminary data indicated that the cleaning solution that contained 10 percent milk left the same amount of residue on both the clean and soiled plates.

Before a stainless steel surface that has been in contact with milk is clean, the milk constituents--protein, fat, lactose, and minerals--

must be removed. Previously, a test for calcium (calcium-analysis method) was developed to determine the amount of calcium remaining on this type of surface. During the past year, a preliminary procedure for determining the amounts of fat and protein remaining on a stainless steel surface was developed. Further work on this procedure is planned.

Previous experiments with dried-milk films indicated that when stainless steel surfaces containing such a film were exposed to 100 percent relative humidity, and then redried, the film was bound tightly to the surface. During the past year, experiments were conducted to determine which of three chemical components of milk solids--calcium, phosphate, or citrate--caused the film to adhere to the stainless steel surface. Known quantities of each of these components were added to the milk before soiling, and tests were made after each addition. However, the data indicated that none of these components was responsible for the tight binding of the film to the surface. Therefore, investigation of this problem will continue.

Publications, Speeches, and Other Reports

Livestock

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ASSEMBLING, PACKING, AND STORING HORTICULTURAL CROPS

Problems and Objectives

The use of inefficient marketing facilities, equipment, and methods has an adverse effect on the returns to producers and on the prices paid by consumers for horticultural crops. Better work methods, techniques, devices, operating procedures, equipment, and facilities are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing, and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Such improvements at shipping points increase the productivity of labor, reduce bruises and injuries, and prolong the storage life of the products. Marketing costs are reduced, and, because the product's salability is increased, the returns to producers are greater.

Major objectives of this research to improve methods, equipment, and facilities for assembling, packing, and storing horticultural crops are to:

1. Reduce the labor and other costs of performing these operations.
2. Protect the products and provide optimum conditions for commercial storage.
3. Develop improved cooling, conditioning, and storage techniques and procedures.

Progress

Citrus Fruits

Photoelectric sorting of citrus fruits.--Conferences were held with personnel from two commercial manufacturers regarding the feasibility of using photoelectric sorting machines for sorting citrus fruits and other products for color and for surface defects. In December, one manufacturer installed his photoelectric sorting machine in a commercial packing line. Company personnel spent considerable time in working out the handling system for feeding fruit through the machine at an acceptable rate. The handling system was developed to handle approximately 22 fruit per second. Sorting tests showed that the machine satisfactorily removed blemished fruit, but not plugged fruit. A comparison of the performance of this machine with that of manual graders showed that, with the exception of plugged fruit, the machine made an error of only 8 percent as compared with 30 percent by manual graders.

A spectrophotometer with a reflectance attachment was used to conduct tests on approximately 100 samples of various varieties of oranges, grapefruit, tangerines, and tangelos. Data were obtained in various portions of the ultraviolet, visible, and infrared portions of the light spectrum, from 250 to 1,800 nanometers. The reflectance of the fruit was then determined from its color and surface blemishes. The data gathered in the tests were used to develop spectral reflectance curves. A study of the curves showed

that several particular wavelength bands in the visible and infrared portions of the spectrum appear to have the potential for detecting various surface blemishes.

Surface injuries such as cuts and plugs are difficult to detect because they tend to reflect approximately the same amount of light as the normal fruit surface. Therefore, tests were conducted in which the fruit were dipped in selected chemical and dye solutions in order to increase the contrast between the cuts or plugs and the normal fruit surface. Spectral curves were run on these samples to determine which wavelengths would best sort fruit with these defects. Although further research is necessary, use of the commercial photoelectric sorting machine showed that the fruit could be sorted successfully after being dipped in the solutions.

Determining pallet box surface temperatures.--A test was made to determine the surface temperatures of pallet box material under conditions that simulated those to which pallet boxes in a grove would be exposed. The materials used were unpainted metal, white painted metal, white painted wood, and unpainted wood. Thermocouples were affixed to all panels. The test was run for six 8-hour days between August 26 and September 4, 1970. Results showed that unpainted metal reached temperatures up to 135° F., which was 25° higher than the temperature reached by unpainted wood.

Deciduous Fruits and Tree Nuts

Brush fruit grader-sizer.--The brush grader-sizer is an experimental, single-unit machine designed to sort, brush, and size fruit, primarily apples, before storage. Tests of the machine in a commercial apple packinghouse showed that a worker's view of the apples is better with this machine than with existing equipment. The special machine section for brushing apples is unnecessary, because the sorting and sizing brushes impart an adequate gloss. The machine oversized the apples and could not be brought to a standard comparable with existing sizers. Since workers had to size apples as they packed, they could not achieve the production rate of workers who packed apples that had been sized previously. Apples were not bruised--not even very soft apples--during the time they were being sorted, polished, and sized. However, some large apples were slightly bruised when they were released by the sizer and let down to the takeaway belt. It was concluded that the brush grader-sizer is not acceptable for final packing of apples for market. However, because it groups sizes without bruising, use of this machine is desirable for pregrading apples before storage.

Apple weight-diameter loss.--This study of apple weight-diameter loss is being conducted because the trays presently used in packing are designed to accommodate apples of a particular diameter and, yet, in the carton, they must total a specified weight. Because apple weight and diameter change during storage, these factors must be considered in the design of the materials used in packing.

In September 1970, six boxes of Golden Delicious apples and six boxes of Red Delicious apples were picked 135 days after full bloom for weight-diameter loss tests. Red Delicious apples in open storage (no liner in the container) lost 4.1 percent of their weight over a 5-month storage period;

apples in containers lined with polyethylene lost only 1.8 percent of their weight. With Golden Delicious apples, the losses in the two containers were 6.6 and 1.3 percent, respectively. These results confirm the value of using polyethylene liners for storing Goldens and indicate that the liners also should be used for storing Red Delicious.

Changes in diameter were much less dramatic. Although Red Delicious in storage lost 4.1 percent of their weight in 5 months, their diameters were reduced by only 1.4 percent; and when stored in polyethylene liners, their diameters were reduced by only 0.3 percent. The greatest loss occurred in the first month and tapered off steadily thereafter.

Handling and conditioning fresh peaches.--Recent changes in handling and conditioning procedures for packing fresh peaches have raised questions that need to be resolved before improved methods and equipment can be developed. These changes are: (1) The widespread adoption of the practice of treating peaches with Botran fungicide for decay control and (2) the more recently adopted practice of hydrocooling peaches in bulk in pallet boxes and holding them temporarily in cold storage. A question arose as to how the holding time of treated fruit is affected by temperature in relation to maturity. Therefore, a laboratory-scale test was initiated to provide the answer. Hale Haven peaches of two maturity levels were used: (1) A firm to soft texture, with the reddish-orange color that is characteristic of ripe peaches; and (2) a firm-to-hard texture, with a greenish background color. Observations of quality were confined to those aspects that are readily discernible by subjective evaluation. Two lots, one at each maturity level, were heat treated for decay control by soaking in water at 130° F. for 2 minutes; two lots were treated for decay control by immersion in 83° F. water containing Botran fungicide; and two check lots received no treatment. After treatment, peaches were held at selected constant temperatures.

The results showed that after 9 days no decay was observed in either of the two maturity levels of treated fruit held at 40° F. and 50° F., whereas slight decay was observed in the more mature, nontreated fruit. The Botran-treated fruit held at 60° F. for 9 days remained in good condition except for slight shriveling, which was probably attributable to lack of moisture in the holding room.

After 12 days, significant amounts of shriveling and physiological breakdown began to appear in all lots; however, no decay or severe softening was found in the treated, less mature fruit held at 40° F. and 50° F. As holding time progressed, the green color disappeared in direct relation to the holding temperature.

Hydrodumper for peaches.--Minor modifications were made to the experimental pallet box hydrodumper for peaches. Then tests of the dumper were conducted using fruit obtained from a commercial peach grower. Preliminary evaluations showed that peaches can be dumped at a rate of approximately 400 bushels per hour, with bruise damage no greater than that caused by current methods. The hydrodumper then was installed in a peach packinghouse at Thomaston, Georgia, and is currently being tested under commercial operating conditions.

Handling and preparing pecans for market.--A major source of economic loss in the pecan industry is the low yield of unbroken half-kernels obtained in commercial cracking and shelling operations. The yield of halves in commercial shelling plants ranges from 60 - 80 percent. Depending upon market conditions, halves sell for 3¢ to 15¢ more per pound than pieces. Processing costs are directly proportional to the yield of pieces, because pieces are more difficult to handle, require additional equipment, and cause more difficulty in the separation of kernels and shells.

Last year's studies showed that conditioning unshelled pecans by soaking them in 140° F. water resulted in a significant increase in the percentage of halves obtained in shelling. Since there was some question as to the effect of this temperature on product quality, this year's research investigated the commercial feasibility of using steam as the conditioning medium.

Preliminary studies are being made to determine the optimum steam processing time for shelling. However, the primary current effort is to develop qualitative, or subjective, methods for measuring pecan quality. Preliminary results indicate that steam actually may extend the shelf life of pecans after they are shelled. This potential is especially significant because of the economic advantages of a steam conditioning process. This process offers the possibility of reducing processing time from 24 hours to 3 minutes, increasing the yield of halves from 60 - 80 percent to 90 percent, and increasing storage stability.

Stacking methods for pear storage.--Storage operators have complained that stacks of cartons containing pears tip over in storage. Usually, packed cartons are stacked on pallets with 2 inches of air space around each carton. A free-standing 1- by 4-inch board is placed on end near each of the four corners of a pallet to support each additional 2,800-pound load when pallets are tiered. As a result, many pallet loads tip as the boards become overloaded. Two improved supports tested were (1) two 1- by 4-inch boards nailed together with a short spacer block at each end and in the middle and (2) one 2- by 4-inch board. Results showed that either of the two supports is adequate to prevent carton tipping. A cooling study determined that although the sturdier supports restricted the flow of air around some of the cartons, pears cooled almost as rapidly as when single 1- by 4-inch boards were used at pallet corners.

Cooling De Anjou pears.--De Anjou pears were used in a test to determine the effect of hydrocooling, as compared with rapid and slow cooling with refrigerated air, on the storage life and ripening response of pears. After being hydrocooled in ice water to a core temperature of 40° F., the pears were packed in polyethylene trays in fiberboard containers lined with polyethylene. The pears to be cooled by refrigerated air were packed before cooling. Hydrocooling reduced the core temperature of the pears from an initial 65° F. to 40° F. in 30 minutes. After being hydrocooled and packed, the fruit was placed in a 20° F. room where the pear core temperature was reduced to within 2° of the storage room temperature within 60 hours. Rapid cooling was accomplished by placing the packed pears in a 30° F. room to permit cooling in the shortest time possible under commercial conditions. Slow cooling was accomplished by placing the packed pears in a room where the temperature was

reduced slightly each day. After these pears reached a core temperature of 35° F. (14 days) they were moved to a 30° F. room. Results showed that none of the cooling rates noticeably affected the soluble solids or titratable acidity of the pears. The hydrocooled pears retained their green color better than pears cooled either rapidly or slowly in refrigerated air; they also ripened more slowly in a 65° F. room.

Potatoes

Powered scooping equipment.--Powered scooping equipment that handles potatoes from bulk bins was studied to determine the damage to the potatoes during handling. Tests were conducted under actual operating conditions with three types of buckets--a narrow side, a wide side, and a slotted side. Sixty samples, representing approximately 10 percent of the potatoes handled, were examined and classified according to damage and percentage of damage. Preliminary results, based on weight, indicate 0.9 percent slight damage; 1.1 percent moderate damage; 1.5 percent severe damage.

Carbon monoxide from bulk scoopers.--Carbon monoxide (CO) buildup in potato storages caused by operation of powered bulk scoops was investigated in cooperation with the Agricultural Engineering Department, North Dakota State University. The combination of propane fuel, normal mixture, and a catalytic muffler produced very low levels of CO and presented the least problem of CO buildup in storages. Other combinations of fuel, mixture of fuel, and muffler showed potential for rapid CO buildup in storage operation.

Systems analysis of packinghouse equipment and operations.--General Purpose Simulation System (GPSS) computer language was studied in detail and is being used to simulate equipment and operations in a representative potato packinghouse. The simulation provides for a detailed analysis of equipment and operator performance under various conditions of product input. The conditions of potatoes that represent their quality are incorporated in the analysis, as well as size and weight. Equipment parameters such as size, speed, type, accuracy, and cost are included and manipulated in the model. Statistical data that concern product flows, queues, times, and costs are provided. The packing line selected for modeling is capable of input rates up to 600 hundredweight (cwt.) per hour. Output is in terms of 100-pound burlap bags and all common consumer packs except boxes. The layout offers some choice of product division and strives for fully mechanized handling of the packed product. Crew size varies from 24 to 35 workers, and over 100 different operations are possible. The packinghouse layout, the process-flow determination and diagramming, and the development of input data and costs are complete. An initial model has been developed and will be refined and verified under contract with the North Dakota State University.

Packinghouse layouts.--Studies were completed of potato packinghouses in the Red River Valley, and guidelines for laying out potato packing lines were prepared. The layouts emphasize mechanization of material handling within the packinghouse and proper planning for future expansion. Included in the guidelines is a procedure for planning special layouts so any packinghouse operator can improve the efficiency of his packing operation. One of the recommended layouts for a packing line having a capacity of 800 cwt.

of potatoes per hour is illustrated on the following page. A new circular-designed potato storage facility was discussed in a feature story at the beginning of this report.

Storing potatoes for processing.--Analysis was completed on previously collected data concerning the rate of potato weight loss during storage as affected by vapor pressure difference, temperature, and time. A temperature of 50° F. seems consistently to cause the greatest weight loss.

Lateral pressures in potato bins.--The study to determine lateral potato bin pressures was continued for the second year. The strain gage pressure panel used last year and an additional pressure panel were installed in a 10,000 cwt. storage bin to permit a determination of the pressures on the 11-foot high end wall and the 18-foot sidewall.

Periodic readings of the pressures were taken after the bin was filled in early October 1970. Potatoes stored against the sidewall panel were removed by March 26, and potatoes stored against the end wall were removed by April 4, 1971. A preliminary analysis of the data obtained during the current season indicates that the lateral pressure on the end wall, 1 week after storage, was about 95 pounds per square foot--slightly less than in the previous year's study. Data for the 18-foot sidewall showed that a maximum pressure of about 130 pounds per square foot was reached at about 4 feet above the floor.

Ventilating bulk bins of potatoes.--The study on ventilating bulk bins of potatoes with air supplied by a cross-flow circulation system was continued. This system was compared with the conventional (vertical) bottom to top "through system." Two types of storages were used--one in a below-ground bin and one in an above-ground bin, each 20 feet wide.

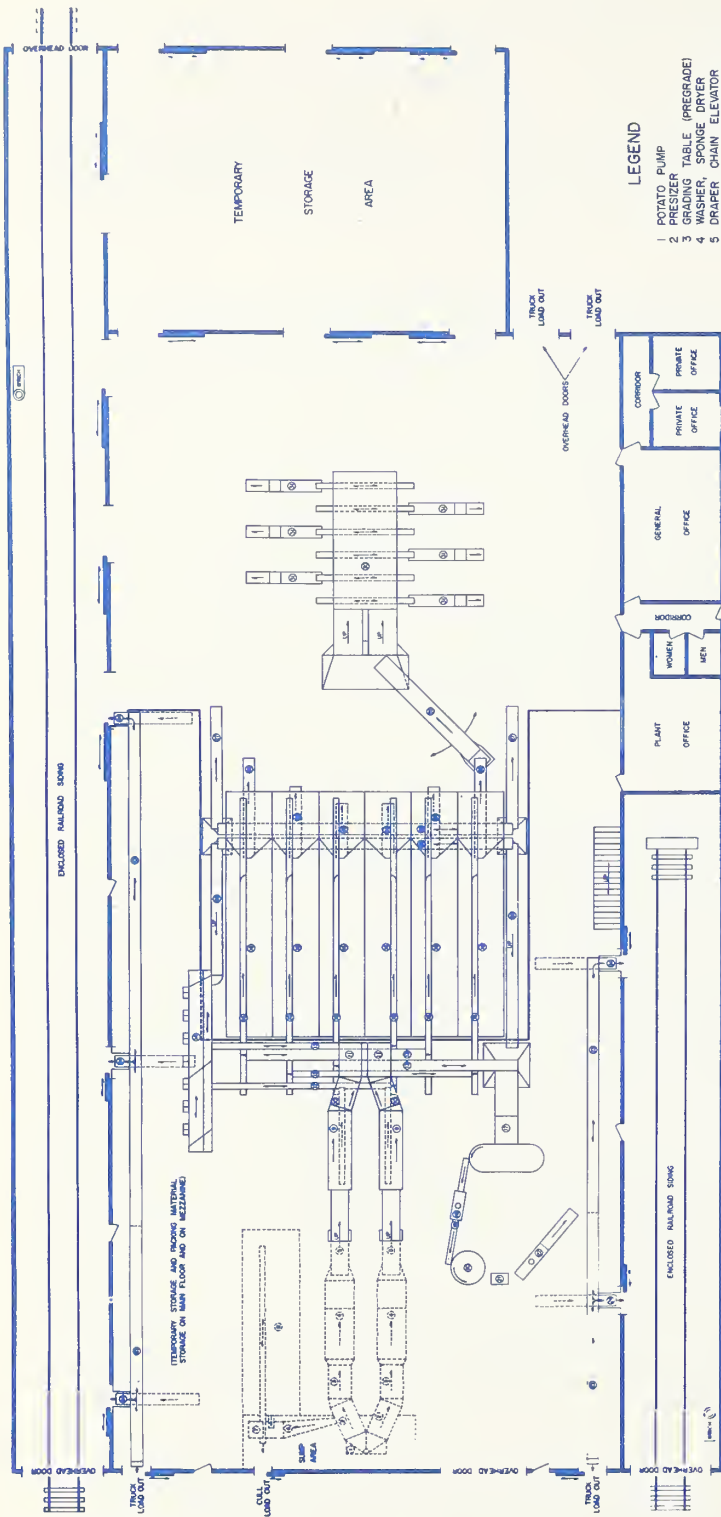
The above-ground, cross-flow bin was provided with dampers which could reverse the direction of airflow. This feature proved to be advantageous when warming was attempted, because the operator was able to adjust the controls to provide more heat to the cooler areas of the bin.

Results showed that control of the air circulation pattern is slightly more difficult when using cross-flow circulation. However, the air circulation pattern did not appear to be a critical factor. No disease development was found in either bin.

Potatoes in the cross-flow bin on the side adjacent to the input air had as much pressure bruising as those in the bottom layer of the vertical flow bin. It, therefore, appears that exposure to input air causes as much pressure bruising as pile depth.

Vegetables

Handling and preparing cabbage, carrots, and celery for market.--Research on handling and preparing cabbage for market focused on obtaining labor and equipment requirements to pack cabbage heads in wirebound crates, the size range of individual cabbage heads within packed crates, and the



LEGEND

- 1 POTATO PUMP
- 2 PULVERIZER
- 3 GRADING TABLE (PREGRADE)
- 4 WASHER, SPONGE DRYER
- 5 DRAPER, CHAIN ELEVATOR
- 6 FLUME FOR CULL POTATOES
- 7 VERTICAL ELEVATOR FOR CULLS
- 8 BIN FOR CULL POTATOES
- 9 HANDING AREA
- 10 FLAT BELT CONVEYOR
- 11 ROLL SIZER
- 12 MOVABLE, REVERSIBLE CONVEYOR FOR NO. 2 GRADE
- 13 MOVABLE, REVERSIBLE CONVEYOR
- 14 RETURN FLOW DISTRIBUTION TABLE WITH CLOSERS
- 15 FLAT BELT CONVEYOR WITH FLOW-OFF
- 16 HOPPER BOTTOM BIN
- 17 AUTOMATIC BAGGER
- 18 SMALL PACK CLOSER
- 19 SMALL PACK CLOSER
- 20 SMALL PACK CLOSER
- 21 BALE CLOSER
- 22 BALE CLOSER
- 23 REVERSIBLE BAG CONVEYOR
- 24 MOVABLE BAG CONVEYOR
- 25 REVERSIBLE FLAT-BELT CONVEYOR
- 26 BULKHEAD ELEVATOR
- 27 CONVEYOR
- 28 BIN UNLOADING CONVEYOR TO SIZER
- 29 MOVABLE (PIVOTING) CONVEYOR TO SIZER
- 30 SIZER (WEIGHT OR SHAPE)
- 31 BOX FILLER-CLOSER

SCALE
0 10 20 FEET

MEZZANINE LEVEL AND MAIN FLOOR PLAN



SECOND FLOOR OFFICE PLAN

Layout for a washing-packing line for potatoes. This layout has an input capacity of 800 cwt. of potatoes per hour and permits packing 100-pound burlap bags, all common sizes and types of small bags, and count-fill boxes.

size range of field-run cabbage heads as they were received at the packing facility.

Based on this information, more efficient work stations were designed and installed along the cabbage packing line of a cooperator's packing facility. With these work stations, the labor required to pack cabbage heads was reduced from approximately 1.3 man-minutes per crate to approximately 0.6 man-minutes per crate.

During the carrot packing season, a fully automatic bagging machine was installed by the manufacturer in a commercial packinghouse in Zellwood, Florida. This machine forms and seals its own bags and automatically weighs and places the carrots in the bags. Trial runs with this equipment indicated that a packing rate of 26 bags per minute can be obtained. This output approximates that of four people using the manual weighing and filling method. Extensive testing of this equipment is expected to continue during the next growing season. This equipment has possibilities for packaging long white radishes and carottes (a variety of very small tender carrots) which presently are packaged by hand in preformed bags.

Research conducted this year on handling and preparing celery for market was directed at developing methods whereby cooperator personnel could be trained to operate safely the semiautomatic equipment designed to remove unwanted petioles from celery stalks. Also, data were obtained on labor requirements for removing petioles manually and by machine-assisted methods. Data collected last year indicated that production rates for hand stripping ranged from about 12 stalks per minute, when two or three petioles were removed, downward to about seven stalks per minute when five petioles were removed. The machine stripping rate remained fairly constant at about 12 stalks per minute. This year some of the better trained operators attained a rate of approximately 15 stalks per minute with the machine-assisted method. Stalk sizes generally were not as large during this year's tests, which probably resulted in the faster rate. Indications are that fully trained operators should be used so that stalk weight will not be reduced excessively.

Precooling sweet corn in unit loads.--The change from manual handling of packed sweet corn in individual crates to mechanized handling in palletized unit loads has precipitated a need for precooling systems designed to accommodate the unit loads. Many precooling plants that already have installed such systems found them to be inadequate.

Research on cooling pallet loads of crated sweet corn was initiated last year to determine the most effective and efficient rate of water flow, spray characteristic of the water, and rate of airflow circulated in conjunction with the water. This year, in tests using medium fine nozzles, a water-flow rate of 100 gallons per minute (g.p.m.) was more effective than one of 50 g.p.m. The cooling rate was found to be correlated directly with the rate of airflow, with maximum cooling occurring at a waterflow rate of 100 g.p.m. and an airflow rate of 3,000 cubic feet per minute per 40-crate stack. Under these conditions, packed sweet corn was cooled from 90° to 41° F. in 1.1 hours with 34° F. water.

Evaporative-convective cooling of sweet corn.--Hydrocooling presently is the most popular method of precooling sweet corn, primarily because it is the most effective and economical method developed so far. However, it requires large quantities of water and has great potential for the rapid spread of decay-producing microorganisms. Increasing emphasis on sanitation in precooling plants, together with the inevitable tighter restrictions on water usage and pollution, requires ways to precool sweet corn with less water and cleaner water.

An evaporative-convective cooling method was designed that provides the cleanliness of air precooling and the speed of hydrocooling, without drying the product; yet it precools at a cost less than for vacuum cooling. The method requires circulating dry, cold air through a thoroughly wet product.

This method was tested in the laboratory by conducting 13 test runs, each replicated three times, on cooling a single wirebound crate of sweet corn. Rates of airflow were 900, 1,800, 2,100, and 2,700 pounds per hour. Dry-bulb temperature values of 35°, 37.5°, 40°, and 42.5° F., were used at each airflow rate while the wet bulb temperature was maintained at a constant 32° F. The cooling rate responded significantly to a change in airflow, but did not respond to the dry-bulb temperature variations. This new method of cooling is now being tested for use in cooling peaches.

Technician starts a test run by activating experimental evaporative cooler.



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IMPROVING THE PACKAGING OF AGRICULTURAL PRODUCTS

Problems and Objectives

The cost of packaging U.S. agricultural products continues to increase. This cost was \$7.3 billion in 1967, \$8.4 billion in 1969, and \$8.8 billion in 1970. ^{1/} However, good packaging is necessary in an efficient distribution system. Moreover, good packaging helps to get products to the consumer in good condition.

Producers were not faced with many packaging problems when they shipped their produce in burlap bags, barrels, baskets, and wood crates and boxes, but today's marketing system is more demanding. Some of the packaging problems that confront agriculture today are:

1. Self-service merchandising is continuing to put pressure on the farmer or packer to package products in consumer packages.

2. More complex materials are being used now in consumer packages and in shipping containers. Most farmers are not knowledgeable about the properties or differences in various types of plastics such as polyethylene, polypropylene, polyvinyl chloride, and polystyrene films which are widely used for consumer packages. The transition from shipping oranges in wooden crates to shipping them in fiberboard boxes was not as difficult as it is for grapes and winter pears, which have to be stacked high in storage for many months. Products that have to be stored for a long time and products such as leafy vegetables that are hydrocooled and packaged wet require sturdy and moisture-resistant, corrugated boxes. Such boxes may be wax coated or wax impregnated, and plastic may be combined with the wax to provide more strength and a greater moisture barrier. However, these more complex materials are harder to recycle or to dispose of in incinerators.

3. Export marketing creates another set of demands for special packaging to permit U.S. products to compete successfully in world markets. Exporters of agricultural products must place products in foreign markets in good condition at the lowest possible cost and in packages and containers that are attractive and meet the needs of the foreign consumer.

4. The mode of transportation used affects the packaging of agricultural products--lighter weight containers are needed for air transportation than for rail or truck transportation, and the shape of the containers may need to be changed to fit airplane configurations.

5. The labor costs for handling are rising. The multiple-unit handling and transportation of containers on pallets or slip sheets necessitates changes in the dimensions and ventilation slots of the containers to make them fit transportation equipment efficiently and to permit adequate cooling of the products.

^{1/} Marketing and Transportation Situation, Economic Research Service, U.S. Department of Agriculture, August 1971.

Most farmers have no more training in the skills of packaging than they have in breeding new plant varieties; and, obviously, hundreds of thousands of small growers of agricultural products cannot undertake individual research to solve these problems in packaging. For this reason a packaging research program was organized to help solve some of these marketing problems. Most of this research program is concerned with packaging perishable products such as fresh fruits and vegetables, fresh and frozen poultry, meats, dairy products, and flowers and ornamentals, but there are many problems in packaging other agricultural products, such as cotton, that need attention.

New or improved consumer packages, shipping containers, and protective coverings are developed, in cooperation with package and container manufacturers, and tested in the laboratory. Then they are evaluated in the marketing system by packing and marketing products in them in cooperation with growers, shippers, packers, transportation and distributive agencies, and, of course, with manufacturers of packaging materials. Evaluation usually consists of (1) determining the cost of packaging materials and all other costs associated with the use of alternative packages or containers, such as the labor required to assemble, pack, close, and handle them, the space they occupy in storage, and the transportation charges; (2) determining their performance with respect to their ability to protect the product from damage or quality deterioration, either by making controlled laboratory tests or by making commercial test shipments; and (3) determining their comparative trade or consumer acceptance.

The objectives of this development and evaluation of new packages, containers, and materials are to find those that: (1) are lowest in cost or contribute to the reduction of marketing costs, (2) protect the product, and (3) improve the salability of the product.

Packaging problems are never completely solved--the perfect package is elusive. Trade and consumer resistances often are encountered. For example, many efforts have been made to develop new bale coverings for cotton and new packages for frozen meats, but trade and consumer resistance to change have negated such efforts. It usually takes several seasons to develop, test, modify, and evaluate a new package or container for perishable products; therefore, research to improve the packaging of specific products is in various degrees of completion as reported below. Research frequently is undertaken on only one product in a group, because the results may be applicable to other products. For example, the results of research to improve the packaging of one variety of dry beans may be applied to other varieties of dry beans or to similar products such as rice.

Progress

Developing Improved Packaging for Poultry and Meat

Fresh poultry.--Marketing Research Report No. 906, "Comparative Performance and Costs of Dry Ice and Water Ice in Shipping Fresh Poultry," was issued in February 1971. This report describes the costs and charges for packing and shipping poultry (1) dry ice packed in fiberboard boxes, (2) water ice packed in fiberboard boxes, (3) dry ice packed in polystyrene foam boxes, and (4) water ice packed in polystyrene foam boxes. The lowest-cost method was

dry ice packed in fiberboard boxes. At the time of the study, it was estimated that general adoption of this method would save about \$15.7 million annually. Most of this saving would result from loading 25 percent more of the dry-ice-packed poultry per truck than water-ice-packed poultry. The industry has adopted this method for about 35 percent of its poultry shipments.

Fresh beef carcasses.--Five transportation tests and a series of laboratory tests, in which fresh beef shipping schedules, temperatures, and packing practices were simulated, were completed under a cooperative agreement at Texas A&M University. These experiments showed that (1) protective wrappings such as polyvinyl chloride film and polyethylene bags reduced shrinkage sufficiently to more than offset the cost of materials and labor and (2) microbial counts were significantly higher on wholesale beef cuts that were packaged in polyvinyl chloride film or in polyethylene bags than on beef cuts that were unwrapped or packaged in crinkle paper bags.

Frozen pork.--Eight refrigerated warehouses were surveyed to identify common methods of handling, packaging, and storing frozen pork bellies and hams. The information obtained was used to plan an experiment that compared the effects of three freezing methods and three packaging methods on weight loss and handling costs for various periods of time in storage. Preliminary results show that the system that resulted in the least weight loss and lowest handling cost for the storage time periods studied was a combination of blast freezing, spray glazing, and enclosing the pallet load of pork in polyethylene bags. The freezing method used appears to be the most significant factor affecting total weight loss for pork during the handling and storage cycle in a refrigerated warehouse.

Beef retail cuts.--Under a cooperative agreement with the Division, Kansas State University studied the costs and salability of retail cuts of beef that were prepared, packaged in a new, completely visible package, and frozen at a central processing plant. Frozen meat display cases were placed in a central position in the display case line in three supermarkets, and frozen and fresh beef cuts were compared as to costs, sales, and consumer acceptance. Cut terminology, cutting methods, and retail prices were kept the same for both fresh and frozen cuts. Twenty-four items were offered for sale in both fresh and frozen form. About one-fifth of the total sales were frozen cuts. The consumer acceptance comparison showed that more consumers preferred fresh meat than frozen meat. However, there were encouraging signs of high acceptance among those who tried the frozen meat.

Frozen beef cuts also were offered for sale in three convenience stores, but sales were slow. Complete analysis of the costs, sales, and consumer acceptance data will be completed next year.

Developing Improved Packaging for Horticultural Products

Apples.--Two packaging innovations were evaluated to reduce costs of exporting apples and to insure better arrival condition: (1) Conventionally used tray-pack boxes that hold 42 pounds of apples were unitized on pallets to achieve more efficient handling and less damage to apples from multiple handlings and (2) pallet bin boxes--four corrugated fiberboard boxes, each

holding 200 pounds of apples--were unitized on a pallet to test the feasibility of shipping apples loose in large containers. The palletizing of the tray-pack boxes reduced bruising damage to the apples, but many unitized pallet loads failed to arrive in overseas markets intact because of loose or broken straps, or damaged boxes or pallets. The costs of packing, shipping, and receiving apples in bin boxes were about \$1 less per 42 pounds (weight equivalent of tray-pack box) than for shipping them in tray-pack boxes. European receivers who prepackage apples preferred the bin boxes. Conventional wholesalers preferred the tray-pack boxes, but want further improvements made in unitizing them.

Asparagus.--Asparagus conventionally is packed in heavy, wooden pyramid crates that weigh 7 pounds each. It usually is displayed loose in retail stores, and spoilage losses are high. A pulpboard tray consumer package was developed and evaluated in cooperation with a package manufacturer. The asparagus was packed in these trays, overwrapped with stretchable film, and packed and shipped in corrugated boxes. It is evident that market acceptance of the packaged asparagus was favorable, as 300,000 one-pound consumer packages of asparagus were shipped from California during the 1971 season to domestic markets and European markets. However, cost studies showed that research is needed to reduce the costs of packing the asparagus in the trays and overwrapping them.

Green beans.--The potential market for U.S. green beans in Europe appears favorable if containers can be developed that will deliver the beans in good condition and at a reasonable cost. Two ventilated, wax-impregnated fiberboard boxes were packed with Florida-grown green beans and test shipped to Philadelphia, Pennsylvania. One box had insufficient ventilation slots, and the other box was not sturdy enough. New boxes will be designed and tested.

Celery.--European receivers complain that the wooden crates used for American celery are too large and cause excessive bruising to the celery. Wax-resin-impregnated corrugated boxes were developed and tested in the laboratory. The newly developed boxes were not sturdy enough to withstand immersion in hydrocoolers. Further improvements in the boxes must be made before they can be used in export test shipments.

Cherries.--An evaluation was made of alternative shipping containers for California-grown, fresh, sweet cherries that were shipped by air freight, and for Washington-State-grown, fresh, sweet cherries that were shipped by rail. The cost of packaging and palletizing materials, direct labor to pack and palletize, and charges for air transportation to ship 18 pounds of California cherries from San Francisco to New York was \$2.71 in wooden boxes, \$2.44 in polystyrene foam boxes, and \$2.42 in fiberboard boxes. The costs of shipping 20 pounds of Washington cherries by rail were \$1.28 for the wooden boxes and \$1.11 for the fiberboard and polystyrene foam boxes. Results of test shipments showed that polystyrene foam boxes were not sufficiently sturdy and the fiberboard boxes either did not permit or maintain adequate cooling of the cherries when they were shipped by rail. More research is needed to develop fiberboard boxes with ventilation slots properly designed in the box to permit precooling of the cherries, and adequate cooling when the boxes are shipped either on pallets or when they are stacked individually in rail cars or trucks. The



Palletized cherries in an airline cargo container.

fiberboard boxes performed very well in air freight shipments made in the summer of 1971.

Grapefruit.--In research to reduce damage that has been occurring to boxes and to grapefruit in shipments to European markets, six different boxes were tested in the laboratory and then were used in test shipments to European markets. These boxes cost from 1.8 to 8.5 cents more per box than the one currently used. They arrived in Europe in excellent condition, but they still caused misshapen grapefruit. More tests are needed to determine whether the capacity of the boxes should be increased and which of the boxes will perform best and at the lowest cost.

Grapefruit halves.--Tests were made to determine whether it is feasible to prepackage ready-to-serve grapefruit halves for distribution in hospitals and for sale in cafeterias. Arrangements were made with package manufacturers and grapefruit growers and packers to prepackage grapefruit halves and market them in institutional outlets on an experimental basis in 1972.

Lettuce.--Research assistance was given to the Department of Defense when they conducted test shipments of prepackaged iceberg lettuce in 1970. When sufficiently cooled, the lettuce that had been wrapped in film and packed in wax-impregnated fiberboard boxes arrived with the least amount of spoilage at overseas military bases in Japan and Germany. As a result of these tests, during the summer of 1971 the Defense Department procured about 15 van container loads per week of prepackaged lettuce packed in wax-impregnated boxes for shipment to the Far East.

Pears.--Expanded polystyrene foam and pulp trays that were designed for apples were tested for pears. Preliminary results show that the use of trays

reduces bruising of the pears; however, especially designed trays should be developed for the different sizes of pears.

Tomato transplants.--Because of the high cost of shipping tomato transplants with peat moss wrapped around the roots, the feasibility of shipping them bare rooted was studied. The total cost of packaging materials, direct labor, and transportation charges for packing and shipping 1,000 plants from Georgia to Ohio was \$2.59 when they were packed with peat moss and Kraft paper wrapped around the roots, but only \$1.81 when the plants were packed and shipped bare rooted. As a result of the research, 60 percent of the Georgia-grown tomato transplants were shipped bare rooted in the 1970 season.

Watermelons.--When watermelons are high priced; e.g., 7 to 10 cents per pound at retail level, it is feasible, economically, to pack and ship them in corrugated fiberboard boxes, instead of handling each melon individually. The savings in labor costs for loading, unloading, and handling watermelons in fiberboard boxes, along with a reduction in damage to watermelons, offsets the additional costs of packing and shipping them in fiberboard shipping containers. Boxed and palletized watermelons were shipped to several domestic markets successfully, and some also were test shipped to England where they met with favorable trade and consumer acceptance. (See feature story on page 10.)

Dried fruit.--Research was conducted, in cooperation with the Forest Products Laboratory, Madison, Wisconsin, to find ways to reduce damage to shipping containers used for dried fruits. Random samples of 12 types of fiberboard boxes used for dried fruit were collected from manufacturers and tested. The tests showed that the top-to-bottom compression strength of the boxes ranged from 1,350 to 2,150 pounds, and averaged 1,650 pounds. High-humidity conditions reduced this compression strength about 50 percent. The tests also showed that, in most boxes, collars or liners were not designed properly and did not act as a unit with the container walls to support overhead weight. It was found also that, under commercial conditions, boxes loaded in register (in straight columns) on pallets performed better than boxes loaded in an interlocking pattern.

Carnations.--The performance of presently used shipping containers for Colorado carnations generally were found to be adequate. Examination of 11,925 carnations in air freight commercial shipments revealed damage to only 2.5 percent of the carnations. Container damage was not found to be a serious problem. The cost of packaging and shipping carnations can be reduced by packing and shipping larger quantities of carnations in a container. The cost of packaging material, direct packing labor, and transportation charges from Denver, Colorado, packinghouses to major United States markets, per flower, was 2.2 cents for 190 carnations packed in the smallest box used by the industry; 1.6 cents for 375 carnations packed in the smaller of two medium-size boxes; 1.5 cents for 500 carnations packed in the larger of two medium-size boxes; and 1.3 cents for 825 carnations packed in the largest box used by the industry.

Roses.--An expanded polystyrene foam box was tested for shipping California cut roses. Because of the insulation value provided by the foam material, only 7 pounds of ice was used in the box, as compared with 15 pounds in the conventional flat-style fiberboard box. Also, less interior packaging

materials, such as mascerated paper, was used in the polystyrene foam box than in the conventional box, which made the tare weight of the foam boxes, packaging materials, and coolant only 4.5 pounds as compared with 12.2 pounds for the conventional box. The cost of packing and shipping roses in the foam boxes was \$1.78 less than in the conventional box. However, the foam boxes cannot withstand rough handling.

A hamper-style fiberboard box also was developed. This box was designed so that the roses would be handled and shipped in a vertical position rather than in a horizontal position as is done in the flat-style fiberboard box. By shipping the roses in a vertical position, it was assumed that less ice or coolant material would be needed if it were placed near the blooms at the top of the box. Five pounds of dry ice was placed directly above the blooms, in comparison with the 15 pounds of water ice generally placed in the middle of the flat-style box on the stems of the roses. However, the hamper-style fiberboard box did not offer as much protection to the roses from extremely cool temperatures and extremely hot temperatures. Advantages of the hamper-style fiberboard box were that it was lighter in weight, lower in cost, and required less packing labor to fill than the flat-style box. The total cost of packing and shipping 500 roses in the hamper-style box was \$3.47 less than in the conventional flat-style fiberboard box.

Standardization of Containers

Since the repeal in 1968 of the Standard Container Acts of 1916 and 1928, there have been no Federal laws that specifically set forth the dimensions of containers or packages in which food products shall be marketed.

The lack of standardization of containers increases marketing costs. Consumers pay for these increased costs that are attributable to avoidable waste--waste caused by the greater expense of manufacturing and inventorying a large number of sizes and types of containers; waste caused by the greater expense of handling odd-size containers in transportation and in storage; and waste caused by losses through damage in transit and in the distributive process because of mixing many sizes of containers.

The food industry faces many serious problems in the development and use of standard size containers. Over a long period of time, many segments of the industry have evolved certain sizes of containers that fit the packing lines, equipment, machinery pallets, etc., that are used in processing, handling, and storing their particular product.

Some of the problems encountered in developing or using standard size containers for unit loads can be summarized as follows:

1. Industry preference for stacking shipping containers on a pallet so that they interlock--in a pattern similar to that of bricks in a brick wall--to hold the containers together as a unit on the pallet, although this type of stacking does not take advantage of the inherent strength of the containers when they are stacked one directly above another in registered fashion (columnar stacking).

2. Lack of a satisfactory method of holding the containers together in a unit. Steel and plastic straps, as well as glue, are used for binding the boxes together, and sometimes the entire unit load is overwrapped in shrinkable film, but each way has some disadvantages.

3. Difficulties in stacking individual containers on pallets in a manner that will allow for adequate air circulation into and around the containers in the unit load.

4. Unavailability of low-cost, sturdy, and serviceable one-way pallets that are easily disposable.

5. Lack of a satisfactory pallet pool or a low-cost pallet return program.

6. Lack of alternative low-cost methods of unitizing loads, other than on pallets, that are suitable at both the shipping and receiving ends of the marketing system.

Developing shipping container sizes for recommendation as standards

Meetings with national and international standardization committees.--Researchers participated in several meetings of the Package Dimensions Committee of the American National Standards Institute and one meeting of the Organization for Economic Cooperation and Development (OECD), Standardization Scheme for International Trade in Fruits and Vegetables. The objective of both groups is to develop sizes of shipping containers and pallets for recommendation as standards to reduce the many different sizes in use and to achieve more efficient use of space in shipping and handling.

Fresh fruit and vegetable survey.--A survey was conducted in two cities, New York and Los Angeles, to evaluate shipping container sizes in use for marketing fresh fruits and vegetables. The number of different sizes of containers found was 371. Several sizes of containers were used for the same commodity. For example, 40 different sizes of boxes were used for apples and 35 for tomatoes. If economies in handling containers in multiple units, such as on pallets, are to be realized, shipping containers must be designed to utilize the space on the 48- by 40-inch pallet efficiently. Of the 371 sizes of containers used in these two cities, only 20 percent were of a size to permit efficient pallet surface utilization (90 percent of the surface of the pallet).

The feasibility of selecting a few sizes of containers for the marketing of all fresh fruits and vegetables was investigated by classifying 50 of the most commonly used containers found in this survey into four group sizes: Small, medium, medium large, and large. The dimensions of the average of these four group sizes of containers roughly corresponds with the dimensions of four containers recommended by the OECD for use in the international trade of fresh fruits and vegetables. The roughly equivalent sizes of containers, by length and width (outside dimensions), that might be adopted for use by the fresh fruit and vegetable industry in the United States are: Small, 16 by 12 inches; medium, 20 by 12 inches; medium large, 20 by 16 inches, and large, 24 by 16 inches.

Meat container survey.--The types and sizes of various shipping containers used for packing and shipping fresh meat and processed meat products were surveyed in four chainstore warehouses in Atlanta, Georgia; Washington, D. C.; Elizabeth, New Jersey; and Hartford, Connecticut, and analyses of these data are underway. The findings will serve as a guide for developing recommended standard size containers for the meat industry.

Designing Containers That Utilize Pallet Space Efficiently

Apples.--New 20 1/4- by 13 3/8-inch boxes (outside dimensions) were developed to fit seven per layer on 48- by 40-inch pallets. The boxes were made from wax-resin-impregnated corrugated board. Laboratory tests showed that the boxes were not strong enough for shipping in unit loads, and improved designs are being developed.

Cherries.--Experimental shipments of cherries were made in corrugated boxes 20 inches long by 12 inches wide. Eight of these boxes were stacked per layer on a 48- by 40-inch pallet. Experiments were made with 16- by 13 1/4-inch corrugated fiberboard boxes. Nine boxes of this size fit on a 48- by 40-inch pallet. These containers were designed for columnar stacking rather than for interlocking on the pallet. Inadequate air circulation was found, and the boxes are being redesigned to facilitate movement of air through the boxes on the pallet loads.

Citrus.--Oranges and grapefruit were packed in 50- by 30-cm. boxes and unitized on 48- by 40-inch pallets and test shipped to Europe. The boxes arrived in good condition and met with very favorable trade acceptance.

Grapes.--Boxes 50 cm. long by 40 cm. wide were developed to fit a 120- by 100-cm. pallet (roughly equivalent to a 48- by 40-inch pallet) and proved very satisfactory in commercial test shipments of grapes. One California grape shipper has ordered one and a half million boxes of this size for use during the 1971-72 shipping season. Experiments were undertaken by other grape shippers in palletizing 17 1/2- by 14-inch boxes on 35- by 42-inch pallets. These shipments arrived in good condition. However, some chainstore receivers did not like this size pallet.

Peaches.--A new, wirebound, wood-veneer box was designed by the Package Research Laboratory to fit a 48- by 40-inch pallet. It holds 48 pounds of peaches instead of the 38 pounds which are packed in the conventionally used box. This box is designed for columnar stacking. Some difficulties have been experienced in keeping the containers registered directly above one another in the unit loads. Different ways of unitizing the boxes on the pallet have been tried, but none have been completely successful. The boxes tend to shift in transit, which allows the cleated end of one box to slide off the cleated end of the box below, which results in crushing the unsupported cover and damaging the peaches.

Pears.--One pulpboard shipping tray manufacturer has redesigned his shipping trays to fit boxes that will fit 48- by 40-inch pallets efficiently. These pulp trays have been tested with promising results.

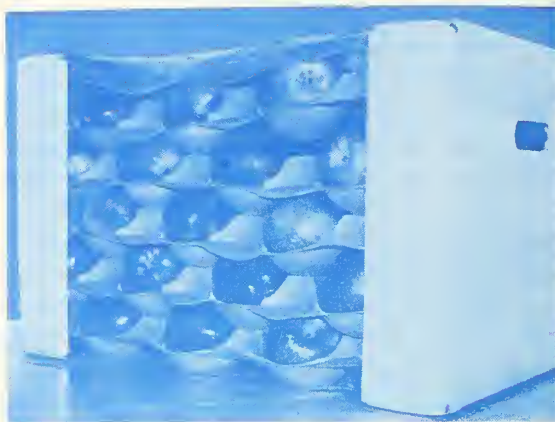
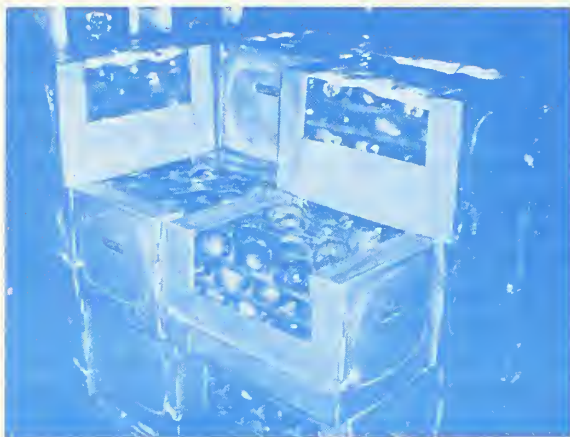
Reducing Package Solid Waste

According to a 1969 study prepared by the Bureau of Solid Waste Management (now Solid Wastes Office, Environmental Protection Agency), the total weight of all kinds of household, commercial, and industrial solid waste generated in the United States in 1966 was 350 million tons. Of this total, approximately 51.7 million tons was package solid waste, consisting of discarded paper, wood, metals, glass, textiles, and plastic materials. 2/

As agricultural production has become more specialized, the distance between producing and consuming centers has increased. Little effort, therefore, has been directed toward the development of returnable containers; it costs too much to transport the empty containers back to the producers. However, as the per capita consumption of packaging materials increases (estimated to be 661 pounds per capita annually by 1976, as compared with 525 pounds in 1966^{2/}), it seems essential that more research effort be directed toward the development of containers with more potential for reuse.

Package researchers participated in a task force committee on Food Packaging Restrictions, Council of Environmental Quality, and they also had numerous meetings with package and container manufacturers and organizations, such as the Society of the Plastics Industry, to discuss ways that packaging materials can be recycled and reused and to plan the research needed in the disposal of package solid waste. Packaging research will be oriented to give more consideration to the evaluation of package disposability and reusability in the future than it has in the past.

Reducing the use of packaging materials



Two shipping containers designed to reduce packaging material solid waste.

2/ The Role of Packaging in Solid Waste Management 1966 to 1976--U.S. Public Health Service Publication No. 1855--by Midwest Research Institute, Kansas City, Mo., under Contract No. Ph-86-67-114, for the Bureau of Solid Waste Management.

Apples and pears.--Evaluations were made of test shipments of tray-packed apples and pears that were packed in experimental, skeleton shipping containers developed by container manufacturers. One container had only partial sides and a partial top. The other had no sides, top, or bottom; the tray-packed fruit was only capped at each end with a corrugated tray. The entire container was wrapped with a shrinkable film. These containers reduced the amount of package solid waste significantly.

Peaches.--Peaches were test shipped on pallets, in wirebound boxes designed to hold 48 pounds--10 pounds more than the conventionally used box, which holds 38 pounds. These new containers use 13 percent less material, per 100 pounds of peaches, than the conventionally used containers.

Test shipments also were made in a 48-pound fiberboard box constructed from paperboard that had been chemically treated to enable it to withstand moisture. These boxes, also, were shipped on pallets and were found satisfactory in limited tests. The advantage of the chemically treated fiberboard box over conventional, wax-impregnated fiberboard boxes for shipping hydrocooled peaches is that it can be recycled for use in other paper products, whereas most wax-resin-coated or impregnated fiberboard boxes cannot be recycled.

Roses.--A hamper-style fiberboard box developed for cut roses uses 11.6 percent less fiberboard in its construction than the conventionally used, flat-style fiberboard box.

Reusing containers and pallets.--The salvage and reuse of containers requires that an adequate quantity of a given size or shape of container be available and that these containers have not deteriorated to the extent that they cannot be reused. Standardizing the dimensions of containers is probably one of the most effective ways of providing for reusability. Containers of odd sizes or shapes in small quantities have little reuse value. Research results which would identify four major sizes on which to standardize all produce containers, if adopted, would provide a large enough supply of empty containers of each size to create a larger reuse market. Receivers then might find enough resale value to call for use, by the shipper, of a better constructed container --one suitable for more reuse. Research is underway to compare the costs of using "throw away" containers, pallets, and pallet bins with the costs of using more expensive containers, pallets, and pallet bins that are reusable.

Disposing of packaging waste.--Plans are being made to accumulate data on the sources, types, and amounts of package solid waste materials accumulated at retail and institutional food service outlets. Methods and costs of disposal will be determined. Researchers also are investigating salvage operations for chainstore operators to determine the salvage value of different kinds of packaging materials and to identify the kinds of packaging material that create disposal problems.

Publications, Speeches, and Other Reports

Comparative Methods of Handling Watermelons--Bulk and Cartons. An Interim Report. J. Varick, G. Close, and L. A. Risse. January 1971. (Cooperative study with the Florida Department of Agriculture, Division of Marketing and Consumer Services)

- Comparative Performance and Costs of Dry Ice and Water Ice in Shipping Poultry. L. A. Risse and J. E. Thomson. Marketing Research Report No. 906, February 1971.
- Dimensional Standardization of Shipping Containers, Pallets, and Transport Equipment. D. R. Stokes. Paper, 11th annual meeting of the Food Distribution Research Society, October 1970.
- Dry Ice in Various Shipping Boxes for Chilled Poultry: Effect on Microbiological and Organoleptic Quality. J. E. Thomson and L. A. Risse. Article, Journal of Food Science, Vol. 36, 1971.
- *Effects and Costs of Packing and Shipping Bare-Rooted Tomato Transplants. L. A. Risse. Paper, New Jersey Statewide Processing Tomato Meeting, February 1971.
- Feasibility of Shipping California Table Grapes in Fiberboard and Polystyrene Foam Boxes and in Polyethylene Mesh Bags. R. T. Hinsch and R. E. Rij. Marketing Research Report No. 871, September 1970.
- Future Developments in Frozen Foods and Fresh Produce Packaging. D. R. Stokes. Paper, National Flexible Packaging Association, New Orleans, Louisiana, December 1970.
- Improved Packaging for Cut Chrysanthemums. J. W. Hagen and R. T. Hinsch. ARS No. 52-52, February 1971.
- New Shipping Containers for Fresh Western Cherries--Costs, Performance, and Trade Acceptance. R. T. Hinsch, J. B. Fountain, and R. E. Rij. Marketing Research Report No. 902, June 1971.
- *Prepackaging--Present and Future. D. R. Stokes. Article, Fruit Trades World Directory, London, England, 1971.
- *Prepackaging Fruits and Vegetables. D. R. Stokes. Summary Report--Produce, Joint Meeting of the National Association of Food Chains and the United Fresh Fruit and Vegetable Association, March 1971.
- *Problems in Packaging, Loading, and Transporting Fresh Fruits and Vegetables Under Refrigeration. L. A. Risse. Paper, Supermarket Institute Produce Buyers School, March 1971.

Radio, Television, and Films

- Television Presentation, NBC's Down-To-Earth Program. L. A. Risse. Orlando, Florida. July 1971.
- Radio Presentation, Packaging Research at Orlando. P. W. Hale. Orlando, Florida. June 14, 1971.

*Not available for distribution.

Radio Presentation, Transportation Techniques Research at Orlando. A. Biales.
Orlando, Florida. June 14, 1971

Radio Presentation, Transportation Equipment Research at Orlando. W. F.
Goddard, Jr. Orlando, Florida. June 14, 1971.

Meetings

Package researchers responded to industry requests to participate in discussions on packaging agricultural products at meetings with the following organizations during the past year:

California Grape and Tree Fruit League Container Committee
Corrugated Container Institute
Florida Citrus Commission Container Committee
Florida Fruit and Vegetable Growers Association
Florida Fruit and Vegetable Handlers Conference
Florists Telegraph Delivery Association
Food Distribution Research Society
Fourdrinier Kraft Institute
Joint Conference of the National Association of Food Chains
and the United Fresh Fruit and Vegetable Association
National Flexible Packaging Association
National Canners Association
OECD-Fruit and Vegetables Standardization of Containers
Oregon-Washington-California Pear Bureau
Packaging Dimensions Committee, American National Standards
Institute
Produce Packaging and Marketing Association
Society of American Florists
Supermarket Institute Produce Buyers Conference
United Merchandising and Management Institute
United Fresh Fruit and Vegetable Association
Washington State Apple Commission
Washington State Fruit Commission
Western Regional Floral Traffic Conference
Western Wooden Box Association
Western Growers Association

IMPROVING THE TRANSPORTATION OF AGRICULTURAL PRODUCTS

Problems and Objectives

Transportation is the lifeline of American agriculture. Without adequate transportation, our modern distribution system for agricultural products, which delivers to the American consumer more and better food and fiber for his dollar than any other system in the world, simply could not exist. Further, without a reasonably efficient transportation system to move farm supplies and equipment to the farms, the highly efficient U.S. agricultural production system we know today would not be possible. In areas of the world where transportation systems are primitive, agriculture is primitive. Where national transportation systems are inefficient, marketing and distribution systems are inefficient and costly. Clearly, then, increasing the efficiency of agricultural production and marketing requires increased efficiency in agricultural transportation.

The cost of transporting U.S. agricultural products from the farms to domestic markets in 1970 was \$5.2 billion, which was more than 10 percent higher than in 1969. Shipments of these products to foreign markets around the world added at least another billion dollars to the agricultural transportation bill. With costs rising for the materials, labor, and money that are needed to provide transportation services, further significant increases in freight rates for agricultural products are inevitable in years ahead.

To help hold down the costs of transporting agricultural products--a cost which will be borne ultimately by the consumer in the higher prices he pays for food or by the producer in the lower prices he obtains for his products--more efficient ways of using the available transportation service must be developed. The transportation research program of the Division is aimed at accomplishing this goal through application of advanced engineering and transportation technology.

To accomplish its purpose, the Division is directing its research effort in this field toward improving transportation equipment and facilities and the techniques of using transportation services so that the greatest benefits can be obtained from them. This research program seeks not only to improve the individual segments and services of the transportation system that are used to move the products to market, but also to fit the total system into the rapidly changing physical distribution system for agricultural products. Further, in reorienting and reshaping the program to help solve other emerging national problems, increased attention is being given to planning and developing new research, such as research to develop more efficient, lower-cost, inner-city food delivery systems and nonpolluting sources of transportation refrigeration.

The problems involved in moving many millions of tons of agricultural products to domestic and foreign markets are numerous and complex. Solutions to them must be found if our domestic marketing system is to remain viable and if we are to meet effectively the increasingly keen foreign competition in world markets.

Improving Transportation Technology

In many instances, solutions to transportation problems do not require the development of new transportation equipment. Frequently, completely adequate solutions can be achieved by adopting new methods and techniques for using existing transportation equipment and facilities. The Division's research program seeks ways to make better use of existing transportation equipment and services to improve the transporting and handling of specific products.

Transporting potatoes.--A study was made of the feasibility of transporting potatoes in large, refrigerated, covered hopper cars in bulk, instead of in conventional cars in 100-pound burlap bags. Performance and cost data



A mechanically refrigerated bulk hopper car used to move agricultural products in bulk to prepackaging and processing plants.

on this method of shipping potatoes were gathered in experimental shipments of potatoes from Bakersfield, California, to Boston, Massachusetts. In the experiments, potatoes were shipped in bulk, in an experimental hopper car, and also, for comparison purposes, in two control cars: a conventional, ice-bunker refrigerator car and a mechanical refrigerator car. Time studies were made of the loading and unloading operations; transit cooling and temperature records were obtained from thermometers in the cars; product damage and spoilage were determined by inspection; and records were kept of the yield of packable potatoes obtained from each of the cars in the experiments.

Shipments in the bulk hopper car had a yield of packageable potatoes that was 6 percent higher than in shipments made in conventional cars in 100-pound burlap bags. Experiments to date indicate that this high yield for the covered hopper car can be improved still further if the conveyor loading and unloading methods used to handle the potatoes into and out of the car are improved.

The findings showed that significant savings were possible in material, labor, transportation and refrigeration costs, and in reduced losses from using the bulk hopper car to move potatoes to prepackaging and processing plants.

The immediate saving from the bulk handling of potatoes was estimated to be about \$960 for a 176,000-pound hopper carload. If the railroads will provide incentive rates for transporting the heavily loaded shipments in the covered hopper cars, additional significant savings in transportation costs to the shipper and receiver would be realized.

Industry acceptance of this method of shipping potatoes has been excellent. Research is continuing on the use of the hopper car for shipping potatoes, onions, carrots, pears, and citrus fruits. Preliminary studies indicate that many other agricultural products can be shipped successfully by this method, and that it will provide greater efficiency and economy than conventional methods.



Transporting and handling citrus fruit.

Research was continued on the transportation and related handling of grapefruit and oranges in bulk in pallet containers from producing areas to prepackaging plants at the terminal market. Four experimental shipments from the lower Rio Grande Valley of Texas to Cincinnati, Ohio, were made during the year to complete the field work on this project. A report on this research is being prepared for publication.

California White Rose potatoes being unloaded directly to the packing lines of a Boston prepacker from a refrigerated bulk hopper car.

Preliminary results of this research show a saving in loading and unloading costs alone of about \$30 a truckload for the pallet-container method over the conventional method of shipping the fruit in 4/5-bushel fiberboard boxes. Moreover, project data which are not analyzed completely yet indicate additional substantial savings in packing, handling, and container costs for the pallet-container method. The arrival condition of the fruit transported in the pallet containers was equal to that of fruit transported in the conventional boxes. However, the shipping experiments indicated that ventilation slots in the triple-wall, corrugated-fiberboard pallet containers are necessary before adequate cooling of the fruit during transportation can be achieved.

Transporting citrus fruit by rail.--Work was begun on an exploratory basis to determine the feasibility of heavier loading of large mechanical refrigerator cars. Two test shipments were made during the year from Florida shipping points to Detroit, Michigan. These shipments, each of which consisted of 1,533 4/5-bushel corrugated fiberboard boxes of oranges, arrived in Detroit in good condition, with very little container and product damage. The conventional load in the smaller, ice-bunker refrigerator car is about 1,050 boxes. The fruit cooled satisfactorily, and product temperatures were maintained at a generally satisfactory level during transit. Savings in transportation costs could be realized by the shippers if incentive rail rates to encourage heavier loading were offered by the rail carriers. The railroads requested that this research be done to find out whether heavier loading is physically

feasible so that they might consider making incentive rates available to shippers. This research will be continued during the coming year.

Transporting loose radishes to overseas markets.--A study was made of the feasibility of shipping radishes from Florida to European markets in selected shipping containers for prepackaging into consumer-size units at the European markets. The study included an evaluation of a 40-pound polyethylene-film bag; a 40-pound nylon, open-mesh bag; and a 50-pound wirebound crate.

The radishes shipped in the polyethylene-film bag arrived in better condition than those shipped in the other two types of containers. Material costs for the 40-pound, polyethylene-film bag were less than for the other two types of containers studied. Total loading, material, and transportation costs were less for the polyethylene-film bags and highest for the wirebound crate. This transportation method is considerably less expensive for the shipper than the conventional method of packing the radishes in small consumer-size bags and shipping them in small, corrugated fiberboard boxes.

Loading patterns for overseas shipments of radishes.--Research on loading problems for overseas shipments of radishes was completed during the year with the publication of the research findings. The new ventilated loading pattern that was developed in this research allows faster cooling of the product, provides greater load stability in transit, and saves \$18 per van container in loading costs as compared with the conventional lengthwise loading pattern for the boxes. The rapid adoption and application of the results of this research by the cooperating shippers has helped significantly in reducing losses and in improving the arrival condition of van container shipments of prepackaged radishes in European markets.

Flowers and foliage.--Transportation costs represent a good part of the cost of moving cut chrysanthemums (mums) from growing areas to the customer. One of the reasons for high transportation costs is the fact that mums are relatively light in weight and occupy more space in an aircraft or truck than many other products. Generally speaking, transporting and handling costs can be reduced if ways can be found to increase the density of the product.

Researchers found that by shipping mums in the bud stage, instead of as open flowers, only about half as much space was required. In addition, it was found that the shipping weight per 1,000 flowers was less for mum-buds and that they could be held in refrigerated storage at destination for as long as 2 weeks, and then opened to full size for sale.

A report of the research, ARS 52-67, "Savings Possible by Marketing Standard Chrysanthemums in the Bud Stage," shows that transporting and handling mums in the bud stage, instead of as open flowers, would result in substantial combined savings to growers, shippers, and receivers. An estimated \$2 million annual saving could be realized on yearly shipments of mums by air and truck from California to Florida.

Similar previous research on shipping carnations in the bud stage showed that a saving of \$2½ million is possible. Thus, the research on transporting

and handling carnations and mums in the bud stage shows potential savings to the flower industry of about \$4½ million per year.

Transporting grain.--It is estimated that the annual cost of transporting grain to domestic and overseas markets, plus loss and damage that occurs in transit, amounts to over \$1 billion per year. In addition, shortages of transportation equipment--particularly rail cars--which were formerly a problem only at harvest time, are now a year-round problem.

Immediate plans are to develop techniques to transport grain in vehicles not normally used to haul grain (cattle trailers, gondola cars, wood chip cars), and to find ways to load and unload boxcars faster. Research has been done to modify general-purpose vehicles so they are suitable for transporting grain and other bulk products. Research on the use of van containers to haul grain and other bulk commodities is underway.

Shipping grain to overseas markets.--The new LAST (lighter-aboard-ship) and the Sea Bees (barge-carrying ships) afford an outstanding opportunity to achieve great reductions in the cost of transporting and handling grains and other bulk agricultural products to overseas markets. In this integrated river-ocean-river system of transportation, shipments of up to 800 tons of grain can be moved directly from inland points in the United States, on an identity-preserved basis, to inland markets overseas. However, techniques for utilizing this new technology should be developed to help obtain the maximum benefits possible for U.S. agriculture. A limited amount of exploratory work was begun late in the fiscal year on the problems of utilizing this technology.

Research is underway to evaluate ocean terminal requirements and loading and unloading problems in Europe, in the Gulf ports, and possibly in other U.S. ports.



View of the Botlek facility at Rotterdam, showing transfer of grain from ocean vessels to small coastal and inland vessels.

Transporting forage crops.--Concentrated forage crops such as hay cubes and feed pellets are being shipped abroad for feeding foreign herds of cattle. However, several problems have been encountered in handling the products in bulk and in van containers. During the year, exploratory research was begun to develop loading methods to utilize space more fully in van containers.

Transporting green hides.--Green hides, which are exported from the United States in large quantities, long have posed a real problem in transportation, because they contaminate the transporting vehicles. Some ocean carriers refuse to handle this freight. Because of the value of this product to U.S. agriculture, and because of the extent of contamination, exploratory research was begun during the year to improve the methods of handling and transporting this product. Studies are being made of the use of ventilated van containers, and of polyethylene as a liner for containers and as a cover for pallets.

Transporting live animals.--The inauguration of the National Railroad Passenger Corporation (AMTRAK) resulted in the discontinuance of many trains, changes in train schedules, and the elimination of enroute station services. These changes in service adversely affected transportation services for the shipment of chicks and bees. Researchers have been consulting with the U.S. Postal Service in an effort to solve some of these problems. Further research will develop alternative packaging and transporting methods.

Truck haulers of livestock frequently transport cargo only one way, which makes the transportation cost for the trip unnecessarily high. Research is planned to find ways for these carriers to utilize available truck space to haul other cargo on the return trip to help reduce transportation costs.

Regulations that apply to the export shipping of live animals in the holds of ships were developed many years ago. Research is planned to determine whether these space requirements may be reduced when animals are shipped by air or in van containers aboard ship. A reduction in space requirements would increase the efficiency of cargo-space utilization and reduce transportation costs. Research is continuing on the development of light-weight, low-cost, disposable shipping containers to reduce the cost of air shipments of livestock.

Urban truck deliveries.--One of the biggest challenges facing food distribution firms in urban areas is how to improve the productivity of their delivery vehicles and drivers. In addition, the general public is concerned that something should be done about the traffic congestion that is aggravated by the great number of trucks on city streets.

The typical, small convenience-type store with sales of about \$4,000 per week may receive deliveries, during 1 week, transported by as many as 70 trucks. Most of these deliveries are relatively small, but they are expensive to the distribution firm, as well as to the store manager, in terms of dollars spent and time wasted.

Research was initiated in the latter part of the year to find ways to improve the efficiency of truck deliveries and to explore the feasibility of consolidating deliveries. Truck delivery operations at stores were observed

in two convenience-type stores in the Washington, D.C., area to determine the number of deliveries, the time required for each delivery, and the time required of the store manager in receiving deliveries. Research underway with several types of vendors includes observing delivery trucks on their routes to learn more about current methods of supplying small food stores.

Improving Transportation Equipment

Because of their inherent nature, many agricultural products require special environments and care during transporting and handling. Frequently, special types of transportation equipment must be used. The efficiency with which the special transportation equipment performs determines, to a large extent, how effectively the environmental requirements of the products are met. Special features and performance of transportation equipment also have an important effect on the costs of transportation and related services, such as refrigeration, on the costs of loading and unloading and on the subsequent handling steps for the products in the marketing system. Such special features also determine, to a large extent, the rates of physical damage and product losses during transit.

Improved refrigeration for trailers and van containers.--(See feature story on page 12.) A new method of testing refrigerated trailers and van containers under load was developed during the year to provide a means of evaluating refrigerated vehicles in a simulated operating environment. The method uses 4/5-bushel corrugated fiberboard boxes packed with plastic balls to simulate fruit. The load can be arranged in various patterns to vary the restrictions on air circulation in the cargo area. Heat is introduced into the load, electrically, to simulate the heat generated by some products in transit. The simulated load can be used to determine the air circulation characteristics of different types of refrigeration systems in the vehicles, in conjunction with different types of loading patterns. More important, however, the load can be used as a standard testing method to measure the performance that can be expected from different types of transportation refrigeration systems when they are actually used under load.

Air circulation studies of a conventional refrigerated trailer revealed that at high delivered velocities (about 2,500 to 3,500 feet per minute) considerable turbulence occurred in the circulating cooled air in the cargo area. Under these conditions there was very little air circulation at the rear of the load, and little or none in the channels throughout the load. However, at moderate delivered velocities (about 1,500 feet per minute) air movement throughout the van and through the load was more uniform. These findings explain the uneven rates of load cooling in conventional refrigerated trailers and van containers, most of which have high-velocity air delivery systems.

The air circulation studies also indicated that static pressures of about 2 to $2\frac{1}{2}$ inches of water are necessary to force the circulating cooled air through the load for heat removal from the cargo. Most refrigerated trailers and van containers that are now in use have static pressures in the air circulation systems of only about 1 to $1\frac{1}{2}$ inches of water.

Additional air circulation studies were made with the simulated loads in our experimental multipurpose van container and in a conventional refrigerated trailer with a modified air circulation system to circulate the cooled

air down sidewall air plenums and deliver it at the bottom of the load as is done in the experimental van. This work showed that better and more uniform air circulation through the cargo area and the load was obtained with this method of air delivery to the cargo area than with the ceiling duct delivery system in conventional refrigerated vans. These air circulation studies were made with both open-stacked loading patterns and closed-stack loading patterns.

Subsequent stationary cooling tests were made with the simulated loads with each type of air circulation system. The results of cooling tests paralleled those of the air circulation studies; i.e., the system in which the delivered air had higher static pressures and in which the air circulation was more uniform throughout the cargo area and the load had the best rates of cargo cooling.

Work in this area is continuing, and the results that are obtained in these stationary tests will be tested further for validity in shipping experiments to domestic and overseas markets. Performance and cost data and other pertinent information will be developed to evaluate each alternative system. It is expected that a report on the preliminary results of this research will be prepared during the coming year.

Waterproof, ventilated hatch plug.--The testing of various designs of "marine-type ventilation hatch plugs" and forced-air ventilation systems was continued during the year. A "marine plug," designated as "C," was developed that would allow outside air to enter the van container and, at the same time, keep sea water out. Various combinations of motor and blower sizes also were tested in conjunction with the "plug" to determine the best combination. An overseas test shipment of grapefruit was made in which the ventilated van container was compared with the marine plug "C" and the forced-air system.

The test results indicated that the grapefruit in the ventilated van container had less damage and decay than those in the refrigerated vans. The ventilated van container can carry 100 more boxes of grapefruit than the refrigerated van containers, which reduces the transportation cost per box. This experimental van also was used for the successful shipment of the first American watermelons ever sent to England.

Use of the forced-air ventilation system with the waterproof hatch plug will make it possible to use the more plentiful, less costly, dry-freight van containers for overseas shipments of products that require temperatures in the range of 50° to 65° F. Ocean freight rates on products shipped in dry-freight vans are only about half as high as freight rates on the same products shipped in refrigerated van containers. In addition to other cost savings expected through use of the ventilated vans, the mechanical refrigeration charge, which is \$40.00 per container by railroad piggyback service from Florida to Norfolk, Virginia, will not be incurred.

Improving load retaining devices.--To determine the effectiveness of metal load retaining bars located at the rear of trailers in preventing damage to shipping containers, an analysis was made of the destination inspection and damage outturn records of 174 piggyback trailer loads of citrus fruit.

Shipments in trailers in which load retaining bars were used had only 28.8 percent of the containers damaged to some extent, whereas shipments in trailers in which the bars were not used had 39.7 percent of the containers in the load damaged. Of a total of 123 shipments that arrived at destination without any reported damage, 61.8 percent were transported in trailers in which the load retaining bars were used.

Comparisons were made in Rotterdam, The Netherlands, of 14 export loads of citrus fruits and vegetables in van containers to measure the effectiveness of load-securing devices. Two tomato loads were evaluated in domestic shipments in which the designated loading requirements of the railroads were used. The costs of material and labor to build braces and the evaluation of the bracing effectiveness have been documented. One test of paper reinforced with cord strapping to secure a load in a domestic shipment of palletized citrus fruit also was made.

Arrangements were made during the year for the development of a captive type, adjustable, load-retaining bulkhead that will be suitable for installation in refrigerated trailers and van containers. A load-retaining bulkhead of this type already is giving good service in some nonrefrigerated vans. However, an effective installation method must be found that will not impair the thermal conductivity of the van before its use in this type of vehicle will be practical. Work on this problem is already underway, and good progress has been made. Research on this development will be continued during the coming year.

Comparison of cryogenic and mechanical transportation refrigeration systems.--A 12-month study of four trailers used in local delivery of perishable foods in the Washington, D.C., area was made. Two of the trailers had nitrogen refrigeration systems, and two had mechanical refrigeration systems. The systems performed about equally well in maintaining the product temperature in the vehicle. The fixed cost was less and the variable cost more for the nitrogen systems than for the mechanical systems. Because of the many variables involved, it was concluded that each manager of a delivery operation must develop his own cost and performance data for his operation under the conditions peculiar to his operation.

The report on this study sets forth the type of data that must be developed, as well as a suggested method for comparing cost and performance of the two types of refrigeration systems.

International standards for refrigerated vehicles.--Researchers continued to work with international organizations in the development of standards for vehicles used to transport agricultural products. One such organization is The Inland Transport Committee of the Economic Commission for Europe (ECE), which has developed an Agreement for test and certification of refrigerated vehicles that operate in Europe. All U.S. refrigerated containers that transport perishable foods between countries in Europe will have to comply with these standards. Through participation in the ECE meetings, the United States was able to change three major provisions of the Agreement. One of these changes resulted in a direct saving of an estimated \$2.6 million to U.S. equipment manufacturers and transportation firms.

Researchers also continued to participate in the work of the American National Standards Institute (ANSI), which develops recommended standards for presentation to the International Standards Organization (ISO). These standards cover both refrigerated and nonrefrigerated van containers that are used in international transportation of foods. The basic objective of the Division's effort in this program is to insure that the standards finally developed for the van containers reflect the specific requirements of agricultural products.

Delivery truck refrigeration.--During summer months, distributors of ice cream and frozen foods have problems in maintaining the low temperature of these products that is required during their delivery from the warehouse to retail stores. The Truck Body and Equipment Association has asked the Division to work with their association in developing better equipment and methods for temperature control so these products can be delivered at the right temperature.

To identify the present methods and problems, exploratory work was begun with an ice cream distributor in the Washington, D. C., area. The objective of the work is to obtain information on product temperatures, number of truck door openings, and length of time the door remains open. This work will be continued in the coming year with other ice cream distributors to obtain information that can be used as a basis for understanding and improving vendor truck delivery operations and for developing improved truck refrigeration equipment.

Adapting Unitization and Containerization to Agricultural Transportation

Unitization provides one of the most effective ways to reduce packaging, transportation, and handling costs for agricultural products. It provides for a few handlings of large units instead of a large number of handlings of many, small individual packages. Unitization for handling and transportation can be accomplished by using large master shipping containers (each of which contains several smaller containers), by bundling and banding the containers together into units (palletized or palletless handling units), and by containerizing van-size lots.

Because of the fragility, perishability, and other special characteristics of many agricultural products, the adaptation of unitized handling techniques to their transportation frequently presents highly complex and challenging tasks.

Unitizing methods for potatoes.--New unitizing, or group bundling methods for 10-pound, consumer-size bags of potatoes were evaluated in this research as possible replacements for the present method of packing five 10-pound bags of potatoes in a 50-pound, multiwall, kraft-paper, bagmaster container. Of the five alternative methods of unitizing the bags studied, the continuous-bag method showed the greatest potential for saving. This potential saving amounted to 50 cents a hundredweight. On the basis of the quantity of potatoes currently being packaged in consumer-size bags of various types, the total potential saving from 100-percent application of the continuous-bag method would be \$25 million a year. In this method, a

continuous line of 10-pound, polyethylene-film bags, joined together in units, can be formed, filled, and sealed automatically by the same machine.

The unitizing methods evaluated in this study were a 5/8-inch-wide plastic band, a 3-inch-wide fiber band, 16-inch- and 24-inch-wide heat-shrinkable, plastic films, and the continuous, polyethylene-film bags. All unitizing methods were tested for 4-, 5-, and 6-bag units of both polyethylene-film and kraft-paper bags under various methods of fastening and sealing the banding materials.

Results of this study suggest that the continuous-bag unitizing method also may have some cost-reducing potential for packing, transporting, and handling consumer-size bags of oranges, and of onions, sweet potatoes, and several other root crops.

Palletizing methods for transporting vegetables.--Research to identify and define the significant problems in palletized loading and transporting of fresh vegetables shipped from Florida showed that most of the containers used for shipping the products do not lend themselves to any type of stacking pattern that will produce compact, stable, handling units. As a result, the palletized units of most of the containers studied showed a tendency to become disarranged and jumbled during transit, which produced some container and product damage and made unloading difficult and time consuming.

The best stacking patterns that could be devised for most of the containers used less than the desired 90 percent or more of the surface area of a 48- by 40-inch pallet. Wasted pallet space results in reduced density of the palletized unit and, in turn, lower load density. Reducing the load density may reduce the vehicle payload and result in increased shipping costs.

Although a few containers can be palletized satisfactorily in shipping, most of the containers studied would have to be redesigned for palletized shipping.

Disarrangement of the palletized units during transportation was more severe in the rear one-third of the load and less severe in the forward two-thirds of the load. Some difficulty was encountered in unloading the shipments because of load shifting and disarrangement, and because the 3 1/4-high stringers on the expendable softwood pallets were not high enough to allow easy access of the tines of the forklift truck for pallet handling.

Unitizing fresh fruits and vegetables.--The effect of using 48- by 40-inch wood pallets for unitization of eight types of fresh fruits and vegetables for shipment in 50-foot mechanically refrigerated railcars, railroad piggyback trailers, and highway trailers was studied. In mechanically refrigerated railcars, shipments of fresh fruits and vegetables normally do not use much of the available loading space. The average amount of available vehicle loading space used by the 11 different shipping containers included in this study was only 55 percent when they were loaded nonpalletized. Yet, with the notable exception of shipping containers used for California oranges and lemons, it is not possible to load as many palletized

shipping containers as nonpalletized containers in railcars because of the interior height of vehicles, the space required for air circulation, or other restrictions.

Lettuce and apple boxes are relatively light in weight but fit so poorly on the pallets that they use only 68 to 69 percent of the available cargo space in trailers. On the other hand, relatively dense packs, such as Florida oranges in 4/5-bushel boxes and Idaho potatoes in 50-pound boxes, use only 59 percent of the space in the trailers, because legal weight limits restrict the number of boxes that can be loaded on a truck.

The principal advantages of using wood pallets for unitized shipments of fresh fruits and vegetables were: They are readily available, and most workers understand their use and are familiar with or can be trained to operate the equipment required to handle them; equipment for handling them is available in most food-handling facilities; and many processing and warehousing facilities have been designed specifically for pallet-handling systems.

Among the disadvantages of using wood pallets are that they each occupy 5 to 6 cubic feet of space, and they are heavy. Hardwood pallets weigh 65 pounds or more, and lightweight expendable wood pallets usually weigh 20 pounds or more. Other disadvantages are that reusable hardwood pallets must be returned to shipping point for reuse; and expendable pallets, if sizable quantities are used, cause a disposal problem.

Transporting frozen poultry to overseas markets.--Analysis of both transit and economic cost data for containerized and break-bulk transportation of frozen poultry from the United States to European markets was completed during the year.

This research indicated that containerized transportation of the product in refrigerated van containers could reduce shipping container and product damage and pilferage losses by as much as 70 percent. Frozen poultry shipped to overseas markets in van containers arrived in better condition than that in break-bulk shipments. The temperature in refrigerated van containers was 0° F. or below for about 95 percent of the transit period. Product temperatures in some of the break-bulk shipments were high enough to cause partial thawing of part of the cargo. The results of this work also suggested that additional economies in shipping poultry could be achieved by using less expensive, lightweight packaging for shipments transported in refrigerated van containers.

Supplying overseas military bases with fresh lettuce.--Research on lettuce shipments was done at the request of the Defense Supply Agency to develop information to guide its officials in procurement and supply operations. Shipping experiments by air and refrigerated van containers from producing areas in California and New York were made to military supply centers in Europe. Cost and product losses for several transportation methods were developed.

The cost of shipping lettuce by air ranged from 27.98 cents to 28.72 cents per pound, as compared with 12.56 to 13.00 cents per pound for shipping

by surface. However, air-shipped lettuce had somewhat less spoilage, and reduced air cargo rates may make air shipment the most economical overall system.

Further research is planned on Defense Department shipments, and the results will be used to assist in developing an overseas commercial market for iceberg lettuce.

Developing Transportation and Packaging Systems for Agricultural Products

The cost of moving agricultural products from farms to consumers can be reduced by improving the efficiency of the individual parts or steps in transporting and packaging agricultural products and by improving the way these steps are put together to make a more efficient total system. Research work has been directed toward improving the individual parts, but marketing is a highly integrated system of many parts, all interdependent. Although much remains to be done on individual transportation and packaging functions, sufficient knowledge has been accumulated for us to find ways to improve the distribution system by rearranging, modifying, or combining the transportation and packaging functions into a more efficient system.

This research work is concerned with synthesizing and testing the feasibility of transportation and packaging systems that embody new technological components or new physical distribution concepts; with identifying important problem areas in transportation and packaging and correcting them in a way that will satisfy market requirements quickly and inexpensively; and with determining points in the marketing system where various transportation and packaging functions can be performed most effectively in order to reduce the overall cost.

Researchers from different fields or disciplines have begun systems research to develop an efficient transportation and packaging system for a few selected products. The steps in this research are: (1) Defining the objectives desired for marketing the specific product, (2) analyzing the costs, technical data, and realistic restraints, (3) studying the existing transportation and packaging system for this product, (4) developing and adapting innovations that improve parts of the existing system, (5) devising alternative systems which offer promise for improved distribution, (6) testing these alternatives for cost effectiveness; and (7) considering subjective factors and preparing recommendations. Alternative systems that offer substantial savings are then implemented on a test basis to demonstrate their effectiveness. Industry and state universities are encouraged to participate in the development of improved systems. In many instances, additional research on specific phases of the systems will need to be conducted.

Transportation and packaging systems for livestock, meats, and animal products.--Conventional methods used for transporting and packaging these products are relatively inefficient because of multiple handlings, the difficulties of handling beef carcasses, and inadequate protection from adverse temperature, humidity, and potential sources of contamination. For example, the Federal Meat Inspection Service annually condemns about 15 million pounds of beef because it is sour, putrid, or contaminated. At the

present beef consumption rate of 115 pounds per person annually, the beef lost from these causes would have provided the needs of 140,000 people for a year.

Research is underway at three locations to compare the costs of distributing fresh beef in carcass vs. boxed form. Some of this work is being done under cooperative agreement at Texas A&M University to evaluate and measure the costs of packaging and handling fresh beef in carcass and boxed forms and transporting it in both forms from the packinghouse to the wholesale distribution center. Five transportation tests and a series of laboratory tests have been completed in which fresh beef shipping schedules, temperatures, and packing practices were simulated.

Other work on this subject is being done under a cooperative agreement with Kansas State University to evaluate and measure the costs of packaging and handling fresh beef in carcass and boxed forms and transporting it in both forms from the wholesaler to retail stores. Detailed costs on chilling carcasses, storing carcasses, breaking carcasses into primals, storing primals, breaking primals into retail cuts, wrapping and labeling retail cuts, freezing retail cuts, storing retail cuts, preparing ground beef, and utilizing byproducts have been obtained from 25 firms in Texas, Oklahoma, Illinois, Kansas, and New Jersey and are being analyzed to determine the cost of various systems.

Under a cooperative agreement with Cornell University, research is underway to identify marketing channels and to evaluate and measure the costs of packaging and handling fresh beef in boxed, wholesale-cut form and cut-up, portion-control form and transporting it in these forms from wholesale distribution centers to hotels, restaurants, and institutions.

During fiscal year 1972, the results of these three studies will be combined into an overall report that will provide a comparison of all costs of distributing beef in carcass vs. boxed form from slaughterhouse to consumer.

Transportation and packaging systems for dry beans, peas, lentils, and seeds.--The conventional method of shipping dry beans, peas, lentils, and seeds in 100-pound bags in the holds of ships is a relatively inefficient shipping system, because multiple handlings of individual bags are required and products are exposed to temperature and humidity extremes and potential sources of breakage, pilferage, and contamination.

Three alternative systems and one subsystem for the export shipment of dry edible beans are being tested. The systems studied are as follows:

1. Conventional shipment in 100-pound burlap bags, in the holds of ships.
2. Shipment in 100-pound burlap bags, or in less costly 100-pound paper bags, in 20-foot van containers (20 feet long by 8 feet high by 8 feet wide).
3. Shipment in a bulk load of 20 tons (without paper or burlap bags) in 20-foot van containers.

Unloading 100-pound bags of Michigan-grown dry beans from ship's hold. Notice longshoreman in center standing on beans spilled from broken bags.



In fiscal year 1971, the feasibility of shipping dry edible beans in 100-pound burlap bags and in 100-pound paper bags in 20-foot van containers was tested in three experimental shipments from Michigan to the United Kingdom. The beans in all the test shipments arrived in good condition. Research workers collected data on temperature and humidity in the containers, as well as on handling and transportation costs, handling practices, and European handling and marketing requirements. The research approach for testing the feasibility of bulk shipments of 20 tons in a van container was



ARS transportation researchers and members of the United Kingdom Research Committee observing unloading of van container and recording the arrival condition of edible dry beans.

planned in the Spring, and the first test shipments from Michigan to the United Kingdom were initiated in June 1971.

Transportation and packaging systems for U.S. citrus fruit.--Present methods of packing and handling California, Texas, and Florida citrus fruit by packing, wholesaling, and retailing firms result in unnecessary handling; citrus fruit is often repackaged at later stages in the distribution system; and it is often exposed to an unfavorable environment.

Research is being done to develop systems that would use new technological improvements, such as pallet boxes and refrigerated bulk hopper cars, and to evaluate and compare new and currently used transportation and packaging systems. These systems include:

1. Packing the citrus fruit in conventional boxes and loading the boxes individually in railcars and highway trailers for shipment.
2. Packing citrus fruit in conventional boxes, unitizing the boxes, and loading the boxes in railcars and highway trailers for shipment.
3. Dumping citrus fruit in bulk into pallet boxes and loading the pallet boxes in railcars and highway trailers for shipment.
4. Loading citrus fruit in bulk directly into rail hopper cars and highway trailers for shipment.

Much research work to compare specific packaging, unitizing, and transporting functions has been completed or is in progress. For example, one study that compared the costs of labor and equipment used to unload individual conventional boxes and unitized conventional boxes was completed in 1971. This study showed that costs of labor and equipment for unloading unitized boxes was one-half of the cost of unloading individual shipping containers. Other completed work measured labor and equipment costs for packaging and transporting Florida citrus fruit. These and other data collected in previous research projects are being analyzed.

Transportation and packaging systems for western pears, plums, and nectarines.--Conventional place-packing and handling, transporting, wholesaling, prepackaging, and retailing of pears, plums, and nectarines are very costly. Place-packing fruits requires much manual labor, multiple handling, and repackaging. Multiple handlings of individual boxes are costly in terms of labor and materials and exposure of the fruits to adverse environmental conditions and potential sources of bruising and other types of product damage. Other packaging systems, such as using the "tight-fill" boxes, or shipping in bulk in pallet boxes and then packaging in consuming areas, have been tried with mixed results.

Research work has been done to measure the costs of and evaluate three alternative systems of marketing western plums, nectarines, and Bartlett pears sold at retail in consumer packages. The three systems differ by location of the prepackaging operation. Five subsystems reflect the

choice of three types of shipping containers that could be made available to terminal market prepackagers and two types of shipping containers that could be available to retail stores. These systems and subsystems for each of these fruits are:

System I: Fruits are consumer packaged at shipping point and distributed through a central warehouse to retail stores.

System II: Fruits are consumer packaged at a terminal market pre-packaging plant and distributed directly to retail stores.

- a. System IIa: Fruits are received at retail stores in standard, wooden, place-pack boxes.
- b. System IIb: Fruits are received at retail stores in tight-fill boxes.
- c. System IIc: Fruits are received at retail stores in 900-pound capacity, 4-cell, pallet boxes.

System III: Fruits are distributed through a central warehouse facility to retail stores, where they are packed in consumer packages.

- a. System IIIa: Fruits are received at retail stores in standard, wooden, place-pack boxes.
- b. System IIIb: Fruits are received at retail stores in tight-fill boxes.

A contract to design and estimate the feasibility of shipping point prepackaging lines for plums and nectarines was completed in 1971. Analysis of the data and publication of a report will be completed next year.

Publications, Speeches, and Other Reports

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Conferences with Trade Associations and Other Governmental
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Air Transport Association of America
American Association of Marine Underwriters
American Bureau of Shipping
American Frozen Food Institute
American Materials Handling Institute
American Meat Science Association
American National Standards Institute
American Sheep Producers Council
American Society of Agricultural Engineers
American Society of Animal Science
American Trucking Association
Association of American Railroads
 (1) Steering Committee of Joint Ad Hoc Committee on Fresh Meat
 (2) Committee on Problems at Origin
 (3) Committee on Problems in Transportation
California Prune Advisory Board
California Raisin Advisory Board

California Table Grape Committee
Containerization Institute
Corrugated Container Institute
DFA of California (Dried Fruit Association)
Defense Supply Agency
Department of State
Department of Transportation
Dried Fig Advisory Board
Dried Fruit Industry Research Advisory Committee
Economic Commission for Europe
Equipment Interchange Association
Evaporated Apple Industry
Fibre Box Association
Florida Citrus Commission
Florida Department of Agriculture
Florida Fresh Fruit Shippers Association
Florida Fruit and Vegetable Association
Fourdrinier Kraft Board Institute
Frozen Meat Committee, American Meat Science
Great Plain Wheat Association
Grower-Shipper Vegetable Association of Central California
Institute of Food Technologists
International Institute of Refrigeration
Iowa Department of Agriculture
Kansas City Board of Trade
Maritime Administration
Maritime Commission
Michigan Bean Commission
Michigan Bean Shippers Association
Michigan Department of Agriculture
Mid-America Governors Council-Transportation Committee
National Association of Meat Purveyors
National Bureau of Standards
National Wooden Pallet and Container Association
Port of New York Authority
Potato Growers Association of California
Produce Packaging and Marketing Association-Education Committee
Railroad Perishable Inspection Agency
Raisin Administrative Committee
Society of American Florists
Super Market Institute
Texas Citrus and Vegetable Growers and Shippers Association
Texas Citrus Exchange
Texas Department of Agriculture
Texas Valley Citrus Committee
Textile Bag Manufacturers Association
The Refrigeration Research Foundation
Transportation Research Forum
Truck Trailer Manufacturers Association
U.S. Army Corps of Engineers
United Fresh Fruit and Vegetable Association

United Kingdom Research Committee
Western Growers Association
Western Weighing and Inspection Bureau
Wirebound Box Manufacturers Association

WHOLESALE, RETAILING, AND INSTITUTIONAL FOOD SERVICE

Problems and Objectives

In January 1970, and again in 1971, \$100,000 of regular funds and \$100,000 of ARS contingency research funds were appropriated by the Congress for the Division's use in restoring, in part, the wholesaling and retailing research which was discontinued on January 1, 1968. The regular funds were used to restaff the area of research, and the contingency funds were used for contracts and cooperative agreements.

Major objectives of the research are to hold down or reduce rising food distribution costs and provide better food services to consumers by:

1. Increasing the efficiency of marketing firms through better operating methods, materials, equipment, layouts, and business practices.
2. Assisting and advising smaller marketing firms to permit them to compete with larger firms.
3. Developing handling practices that will permit food to reach consumers in a clean, healthful, and salable condition.
4. Using the results of these studies to provide inputs for research designed to develop advanced physical distribution systems.

Progress

Wholesaling

Evaluating alternative methods for the servicing, by grocery wholesalers, of small store grocery orders.--Research is being conducted, under contract, to develop efficient and low-cost methods for use by grocery wholesalers in assembling and delivering small store orders. Handling small store orders results in small-lot deliveries, excessive handling, multiple stops with many trucks each day, inadequate inventory control, and exposure of products to excessive damage and pilferage. All of these factors make the grocery wholesaler's handling costs higher for servicing small stores than for servicing their larger competitors. Ways of making improvements in the servicing of small store grocery orders, through the use of better equipment, better loading and unloading methods, improved routing and scheduling, containerized deliveries, consolidation of small lots, and other modifications of existing practices, are being determined and evaluated.

Evaluating operational efficiency for full-line wholesale warehouses.--(See feature story on page 14.) In the first phase of this project, two systems for handling groceries--warehouse pallet and mobile cart--were evaluated and a cost comparison was developed. The results showed that the cart system cost \$81.47 per 1,000 cases delivered 30 miles from the warehouse, and the pallet system, \$92.96--a difference of \$11.49. Although the pallet

system cost more, this system offers the possibility for backhaul income, because empty pallets take up only a small amount of the usable trailer space, and the remaining space can be used to transport merchandise on the return trip to the warehouse. For a 60-mile round trip, the pallet system would cost less than the mobile-cart system when backhaul of more than \$11.49 per 1,000 cases shipped is available. The availability of backhaul should be a key factor in deciding whether to adopt a pallet system, a cart system, or a combination of these systems.

In a second phase of this project, costs were compared for constructing, equipping, and operating grocery warehouses that have 25 feet of clear stacking heights with those that have 21 feet. With increasing costs, especially land costs, many firms have been considering incorporating greater stacking heights into their warehouse design than the conventional 18 to 21 feet. A contractor's study of the problem has been received; however, since the study was conducted, fire and safety regulations have been instituted that greatly increase the cost of constructing warehouses with greater than the conventional stacking heights. Supplemental data will be collected to revise this study, and a report will be prepared during FY 1972.

In the third phase of this project, a model will be developed and recommendations will be made for an advanced mechanized grocery warehouse operation for 1980. The model will emphasize design criteria and performance characteristics. Members of the food distribution industry will be able to use the model to develop their own mechanized operations or to determine whether mechanization will be economical in their operations. A contract has been awarded to develop time and cost standards for advanced mechanized warehouses currently in operation, to determine possible future trends in costs in grocery warehouse operations, and to develop the model. The final report on this subject will be prepared during FY 1972.

Retailing

Optical scanner used in computerized checkout system evaluated in laboratory test.--An optical scanner--a key component in a computerized checkout system for retail food stores--was tested by the Division for 3 months under laboratory conditions and found to work well. Results indicated that use of the system could reduce, by about 5.5 percent, the operating costs of a supermarket with an annual sales volume of \$4 million. This estimate excludes the costs for implementing the system and the potential additional economic benefits from having current, accurate, product and management information. Expressed as a percentage of sales, the estimated potential savings would be between 1.2 and 1.5 percent. These potential benefits include an increase in checkout productivity of about 19 percent, a reduction in checkout errors of about 57 percent, and a reduction in the time required to train checkers of about 33 percent. A detailed description of the system and the results of the study are reported in a bulletin prepared under a cooperative agreement with Indiana State University. The bulletin "Computerized Checkout Systems for Retail Food Stores," MIB No. 3, April 1971, was published by Indiana State University and is available from either the University or the Division. A contract has been signed for a followup evaluation of the system, under actual store operating conditions, to verify the estimated findings.

Improving operations of small food stores.--The operating problems of small retail food stores in urban, low-income areas and in rural areas are being studied in an effort to make the stores more competitive and to lower distribution costs and the cost of food to the consumer. A small retail food store with a weekly sales volume of approximately \$4,000 may receive as many as 60 to 70 truck deliveries of merchandise each week. Most of these trucks deliver only a few cases of merchandise per stop. The costs that relate to labor, traffic congestion, delivery equipment, delay time, and small order deliveries combine to form an expensive process that adds considerably to distribution costs. A cooperative agreement has been initiated with the Pennsylvania State University to evaluate present receiving methods for these small stores in both inner city and suburban areas. Studies are underway to investigate the ordering, receiving, and stocking procedures of these stores and to improve their merchandise selection and operating efficiency.

Developing layout guidelines for supermarkets.--New supermarkets are becoming larger, carrying expanded lines of merchandise, and, in some instances, including new departments. At the same time, labor costs have been increasing and gross margins declining. Under these conditions, a good layout that will ensure operational efficiency becomes very important. A poor layout can cause unnecessary costs in labor, handling, and spoilage of merchandise. In addition, it can result in a low level of sales by failing to provide for adequate display of the merchandise in the store to insure proper customer exposure. Under a cooperative agreement with the University of Missouri, research is being conducted to develop guidelines for developing efficient supermarket layouts. At least 25 food firms, representing all parts of the country and a cross section of the industry, are cooperating in this study. The research will include an evaluation of methods, procedures, and guidelines being used by their store design personnel and a selection of their best layouts. The data collection will be completed during fiscal year 1972 and a report will be prepared containing recommended guidelines for developing a good layout, as well as recommended layouts for at least three sizes of supermarkets.

Institutional Food Service

Developing an integrated management information system (IMIS) for restaurants.--IMIS, an integrated management information system, is being developed for fast-food and coffee-shop restaurants. IMIS will enable food service operators to forecast the labor, food, and overhead costs for specific menu items for a future time period. Preliminary research findings from six fast-food operations indicate that potential labor savings of 25 percent could be realized by improved scheduling and methods through use of IMIS. Additional savings should be realized by ordering food in more economical lot sizes to reduce spoilage loss, decrease handling costs, and increase utilization of storage space. Preliminary research findings for coffee-shop restaurants should be available by January 1972. It is anticipated that corresponding cost reductions could be realized in these restaurants.

Determining improved methods for dishwashing systems.--Research is underway to determine the costs for labor, equipment, and supplies for four types of dishwashing systems and to develop improved work methods, operating practices, equipment layout, and equipment design. Initial findings indicate that labor in dishrooms is utilized only 50 to 60 percent of the scheduled time. Implementation of research findings should reduce operating costs by about 30 percent.

Publications, Speeches, and Other Reports

Wholesaling

Cutting the High Cost of Order Assembly. J. C. Bouma. Institutional Distribution Magazine, December 1970.

Efficiencies of the Methods Used To Ship Groceries From Warehouse to Retail Stores. J. C. Bouma. Annual meeting of the Super Market Institute, Houston, Texas, May 1971.

Efficiency of Various Methods for Shipping Groceries From Warehouse to Retail Store Shelves. J. C. Bouma. Warehousing seminar, National-American Grocers, Montgomery, Alabama, October 1970.

Feasibility of Mechanical Price Marking of Groceries at the Central Warehouse. J. C. Bouma, H. F. Krueckeberg, and R. L. Bailey. MRR No. 872, December 1970.

Principles for Improved Frozen Food Handling. J. C. Bouma. Warehousing workshop, International Foodservice Distributors Association, Buffalo, New York, June 1971.

Retailing

*Changing Patterns of Agricultural Marketing and Transportation. R. W. Hoecker. Marketing seminar, Virginia Polytechnic Institute, Newport News, Virginia, April 1971.

Checkout by Computer. H. S. Ricker. Agricultural Research, Vol. 19, No. 5, November 1970.

*Computer Checkout System. R. W. Hoecker. Commissary store conference, U.S. Marine Corps, Washington, D.C., March 1971.

*Computerization Meets the Consumer at the Checkout. R. W. Hoecker. Agricultural marketing seminar, American Marketing Association, Washington, D.C., March 1971.

Computerized Checkout Systems for Retail Food Stores. H. S. Ricker and H. F. Krueckeberg. Indiana State University, Management Information Bulletin No. 3, April 1971.

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The Low Cost Store--A Profile. H. S. Ricker. Annual convention of the Food Merchandisers of America, Inc., Atlanta, Georgia, October 1970.

*The Role of the Economist in Food Distribution Research. R. W. Hoecker. Seminar, Pennsylvania State University, University Park, Pennsylvania, February 1971.

Institutional Food Service

*Evaluate Employee Productivity With Work Sampling. J. F. Freshwater. Texas Restaurant Association, Austin, Texas, October 1970.

Labor Utilization and Operating Practices in Table Service Restaurants. J. F. Freshwater. Marketing Research Report No. 931, September 1971.

Radio, Television, and Films

**Optical Scanning Computerized Checkout System. 16mm., silent, color, work print with script, 11 min., April 1971. Has been shown at the following locations:

Department of Agricultural Economics, Pennsylvania State University, University Park, Pennsylvania, February 25, 1971.

U.S. Marine Corps, Commissary Stores conference, approximately 25 people. Washington, D.C., March 18, 1971.

Japanese Self Service Association seminar held in Washington, D.C., about 12 people, May 7, 1971.

Associated Food Stores, Inc., meeting of member retailers, Salt Lake City, Utah, May 15, 1971.

Associated Food Stores, Inc., meeting of 100 member retailers, Union City, California, June 18, 1971.

*Not available for distribution.

**Available for loan by writing Dr. H. S. Ricker, USDA, ARS, TF, Federal Center Building, Hyattsville, Maryland 20782.

Press Conference. Demonstration of the computerized checkout system for retail food stores that the Division evaluated. Taped for television by WRC, Channel 4 (NBC) and WTOP, Channel 9 (CBS). Guest speakers were: Virginia Knauer, The President's Advisor on Consumer Affairs, and Dr. G. W. Irving, Administrator, ARS. Hyattsville, Maryland, August 1970.

Radio Broadcast. ABC Network, Los Angeles, California. Dr. H. S. Ricker was interviewed by phone for information on the computerized checkout system for use on a newscast.

HEADQUARTERS
Federal Center Building
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Maine, Orono (Potatoes).....	Earl C. Yaeger
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Minnesota, E. Grand Forks (Potatoes).....	Lewis A. Schaper
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Mississippi, Stoneville (Cottonseed).....	Lloyd L. Smith
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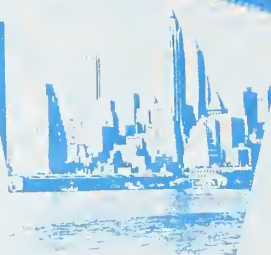
Rotterdam (European Transportation and Packaging)....	Russell H. Hinds, Jr.
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NEW YORK CITY

SALE

TRANSPORTING
PACKAGED FROZEN POULTRY
TO EUROPEAN MARKETS
IN VAN CONTAINERS
AND BREAK-BULK SHIPMENTS

AN INTERIM REPORT



A CENTRAL PACKING-PRECOOLING
SYSTEM FOR CILERY

Cattle Killing-
Floor Systems
and Layouts

METHOD FOR

REFRIGERATED
TRAILER
BODIES

HAULING PERISHABLE FOODS

NO. 10-118

Food
Facilities of
San
Francisco



FEASIBILITY OF A PHYSICAL DISTRIBUTION SYSTEM MODEL
FOR EVALUATING IMPROVEMENTS IN THE CATTLE
AND PRESH BEEF INDUSTRY

IMPROVED METHODS OF
DISPLAYING AND HANDLING PRODUCE
in Retail Food Stores



GROCERY WAREHOUSE
LAYOUT and EQUIPMENT
for MAXIMUM PRODUCTIVITY



Layout, Equipment, and Work Method
for School Lunch Kitchens
and Serving Lines

HANDLING
GROCERIES
FROM
WAREHOUSE
TO
RETAIL
STORE
SHELVES



PIGGYBACK
TRANSPORTATION
of Florida
Citrus Fruit

• PROBLEMS
• METHODS
• EQUIPMENT

NEW SHIPPING CONTAINERS
FOR *Plums*



RESEARCH REPORTS

1954